Learner-Centred Science Teaching in Community Secondary Schools in Tanzania

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To Holy Spirit sisters and Franciscan Sisters
Thank you so much
for supporting my secondary education.
Mungu aendelee kuwabariki.

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Foreword

My ordinary level secondary education (lower secondary school) took place in a school located in a rural area, with few arts teachers and only two science teachers for the whole school. The school had no library or laboratory, and we had few textbooks. Most of us were very much interested in science when we started school, but, as time went on, the subject became tougher and tougher, and we encountered ever-increasing difficulties in understanding. We were studying subjects with few resources and, then, in an unfamiliar language of instruction. In most cases, we had to make sure we remembered the definitions of terms and the phrasing of specific scientific laws or theories, with little or no understanding of the meanings behind these ideas. I did not experience any practical work in my lower secondary school years. I used to learn science by the "alternative to practical" approach. In that approach, we had to read and remember what would have happened when a certain reaction took place. At the end of 4 years of secondary school, only 3 students out of 72 had passed the science examinations and proceeded further with any science subjects. I also had similar observations in my high school. I was studying in a government-owned school. In high school, we had well-equipped science laboratories and libraries with nice science books. Nevertheless, our major problem at high school was a lack of science teachers. At the beginning, we had only one biology teacher, and I was studying physics, chemistry and biology. In most cases, we studied the theoretical parts of the subjects by reading books and past papers from previous examinations, guided by fellow students who had tuition in town during holidays. The part-time teachers would come from nearby schools to teach us experiments to prepare us for the examinations. Such experiences were the motivation for my chosen topic of study. My experiences as a science student in under-resourced schools played a big role in my topic selection for the PhD.

Summary

Learner-active involvement in science learning is an important aspect of science education research around the world. This thesis aimed to study the realisation of learner-centred science teaching in certain community secondary schools in Iringa municipality in Tanzania. The schools I studied had various challenges, including limited resources and the use of a foreign language—one not fully mastered by the students—as the language of instruction. Thus, this study also explored the opportunities for learner-centred teaching in schools with similar contextual challenges. Previous scholars have linked learner-centred teaching to inquiry-based science teaching, students' engagement in critical thinking skills, and students' intrinsic motivations in science learning. Studies suggest that, in science education, students need to be involved in the kind of active learning offered by inquiry-based science teaching and a focus on critical thinking skills to be motivated. To address the aim of my study, I developed 3 research questions that I answered in three distinct articles:

1. What role do contextual factors play in the practice of inquiry-based science teaching, specifically in the Tanzanian context?
2. What are the potentials for inquiry-based teaching in community secondary schools in Tanzania?
3. What motivates students when they are learning science in schools with contextual challenges?

In article I we aimed at exploring the practice of inquiry-based science teaching in schools with contextual challenges. This study focusses on the first research question of my thesis. In this study, we interviewed 11 Tanzanian teachers; we observed 7 of these interview subjects in their practical work, using observational notes to record the sessions. The use of observational notes was a triangulation strategy to enhance the credibility of the findings. A framework by Jiang and McComas (2015) guided the identification of levels of inquiry-based science teaching in our data material. In our analysis, we identified students' levels of active involvement in the stages of inquiry-based science teaching. These levels were developing an investigation question, designing an investigation, conducting investigation activities and drawing conclusions. Our main finding from this study disclosed that the experiments students performed in science classrooms were mostly recipe-based tasks, focussed on students' memorisation of scientific facts and aimed at preparing students for examinations.

In the schools studied, students seldom engaged the higher levels of inquiry, such as asking investigation questions and designing investigations. The contextual challenges constraining the practice of inquiry-based science teaching include limited resources, language barriers, facts-based examinations, teachers' knowledge and beliefs with regard to inquiry-based science teaching and hazardous chemicals used for experimentation (reservations about exposing students to the hazardous chemicals used for experimentations). One of our findings disclosed that locally available materials and investigation questions linked to students' experiences can be used to facilitate inquiry-based science teaching in the schools. From these findings, I argue that, for effective practice of inquiry-based science teaching in schools with contextual challenges like those identified in this study, lab work should not be the only focus for engaging students' in inquiry-based science teaching. Resources from students' surroundings and questions that link science and students' daily lives can be utilised for inquiry-based science teaching.

Article II addresses the second research question, aimed at exploring the potentials for inquiry-based science teaching in Tanzanian schools. The study focusses on questioning in the lessons and students' engagement in critical thinking skills. We conducted this study in 4 schools. The major contextual challenge that was the focus of this study was the use of a foreign language that is not sufficiently mastered by students as a language of instruction. The data materials were video filmed of 6 teachers for approximately 16 hours of their practical sessions and lecture sessions. We interviewed the 6 teachers and the 18 students engaged in these videos after they viewed the video clips. Observational notes were also used to enrich the credibility of the study results. The findings of this study have revealed that it was difficult for students to be engaged in critical thinking skills, such as problem solving, open-mindedness, backing claims with evidence and asking questions for clarification, owing to contextual cultural challenges, particularly the distance between the government education authorities and the teachers and between the teachers and the students. Teachers have to respect the authorities, and, sometimes, this expectation can limit their abilities to engage students' in critical thinking. Also, in African and Tanzanian contexts, teachers are more authoritative; they can hardly share power with students. This expectation creates a classroom setting that cannot adequately facilitate students' engagement in critical thinking skills. Teachers' insufficient understandings of the nature of science and the use of an unfamiliar language for instruction were other limiting factors for students' engagement in critical thinking skills. When students were allowed to do investigations in a less restrictive classroom setting, using resources from their surroundings and answering open-ended questions in Swahili (a more familiar language for the students), they were better engaged in critical thinking skills. From these findings, I argue that, to engage students in critical thinking skills, the classroom context needs to be less restrictive and allow students to engage in various tasks using varied resources from their own communal contexts, including languages familiar to them.

Article III focusses on the third research question, which explored what motivates students when they are learning science in schools with contextual challenges. The study examines the contextual challenges in certain Tanzanian schools, motivating factors for the students learning science in these schools and students' suggestions with regards to enhancing students' motivations in science learning. 46 students, purposefully selected from six schools, participated in group interviews. We conducted six group interviews (one in each school). A group interview lasted for one to two hours. During data analysis, we generated categories and themes from students' responses, which were linked to and discussed with our theoretical framework, derived from various previous studies, on students' intrinsic motivations. The findings disclosed that students in the studied schools have various challenges in science learning, which include limited resources, the use of an insufficiently understood language for instruction, teacher-centred transmission approaches to teaching, and the large amount of content to be covered. Approaches that were suggested by students to motivate students in science learning involved using discussion and questioning approaches and using resources from students' communal contexts to facilitate students' investigations, including the incorporation of aspects from contemporary life into the curriculum, the use of concrete and real-life examples and teachers' use of inclusive approaches in science teaching. Our findings have disclosed that, to make science interesting in the schools studied, students need to be actively involved in learning. From the findings of this study, I argue that learner-centred teaching that is well-planned and thoroughly integrated in the policies of education, curriculum and classroom activities is essential for students' intrinsic motivations in science learning.

The three articles together contribute to the practice of and opportunities for learner-centred teaching in community secondary schools in Tanzania. They all suggested that, for the appropriate realisation of learner-centred teaching in a Tanzanian context, background and contextual factors, such as language, culture, contemporary issues and resources, need to be considered when planning and executing teaching. From the findings of this thesis, I argue that the use of learner-centred teaching relevant to the Tanzanian context, such as utilising locally available materials to generate students' investigations, utilising open-ended questions and linking those questions to students' daily lives and contemporary issues, can make students intrinsically motivated in science learning and contribute to scientific literacy in the country.

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1.0 Introduction

1.1 Context of the study

This thesis focusses on learner-centred teaching in community secondary schools in Tanzania. The thesis explores the current situation and promising opportunities for the practice of inquiry-based science teaching, students' engagement in critical thinking skills and students' intrinsic motivations in science learning. Although the study was conducted in a Tanzanian context, the topic studied is not confined to Tanzanian community secondary schools. The issue of learner-centred teaching is an important topic for the international audience; as such, this study offers several specific contributions in the field of science education. The main contribution of my thesis is in the approaches that can facilitate realisation of learner-centred teaching for schools with contextual challenges. Before presenting the background of my study, I provide a brief explanation of Tanzanian education, starting with the general aims of education, the schooling system and the language of instruction.

Several aims of education were stipulated in the 2005 curriculum for ordinary level secondary education in Tanzania. I will review those aims of education in Tanzania which are most closely linked to my present study. One of the aims is to promote the development of human resources for appropriate utilisation of natural resources; this development aims to improve the wellbeing of the nation (MoEVT, 2005). Education in the Tanzanian context is geared towards ensuring the capability of future citizens to develop and utilise resources for their own development and that of the nation. Also, the promotion of national culture is mentioned among the aims of education in Tanzania (MoEVT, 2005), which suggests that Tanzanian students are expected to learn culturally relevant information and be able to link what they learn to their own cultural and communal contexts so that they can both appreciate and further develop their cultures. Students' acquisition of literacy in various fields, such as vocational, technical and scientific, is also among the aims of education in Tanzania (MoEVT, 2005). Among the stipulated aims of education is the promotion of an inquiry-mind in each student (MoEVT, 2005), which implies that students are expected to be involved in inquiry-based teaching that can facilitate students' attainment of critical thinking skills. These objectives have been touched upon in various ways in the exploration of learner-centred teaching in Tanzania. For instance, I explored students' engagements in inquiry-based science teaching and critical thinking skills, which are important for their acquisition of scientific literacy.

Also, I identified culturally relevant aspects of the science curriculum, during this study, and examined their contributions to students' intrinsic motivations in science.

The structure of formal education in the Tanzanian context, as proposed by the new 2014 educational and training policy of Tanzania, involves 1 year of compulsory, pre-primary education for children aged between 3 to 5 years (MoEVT, 2014). Also, the 2014 policy proposes a change to the current education system where compulsory free primary education will take 10 years. The suggestion put forward by the 2014 policy on years of schooling is not yet fully operational. The formal education structure which is currently operational, as stipulated by MoEVT (2005), involves 2 years of pre-primary education, 7 years of primary education, 4 years of ordinary level secondary education, 2 years of advanced level secondary education and 3 years or more of tertiary education (MoEVT, 2005).

Tanzania is a multilingual nation with 120 vernacular languages, but Swahili is a familiar language for the vast majority of Tanzanians (Brock-Utne, 2000). However, Swahili is not well-promoted as a language of instruction in Tanzania; it is only used for teaching in primary education, while the English language is used as the language of instruction in secondary and tertiary education (MoEC, 1995). This standard resulted from the colonial rule in Tanzania which put less emphasis on developing African languages. The education promoted in Tanganyika[1] during German and British colonial rule aimed at realising colonial interests, such as securing raw materials, markets for the colonizers' goods and labour to facilitate production of raw materials (Mushi, 2009). Tanganyika was colonised by Germany in the period 1886-1920, and, during that time, Swahili was endorsed as a language for teaching in primary schools for the four years of primary education prescribed for African children (Brock-Utne, 2000). During the British colonialism in Tanganyika, from 1920-1960, Swahili was used as a language of instruction in primary schools until the early 1950s, when English was introduced as the language of instruction in standards 7 and 8 (Brock-Utne, 2000). Swahili was declared the medium of instruction in primary education during the introduction of education for self-reliance in 1967. Due to the inconsistency of the use of both English and Swahili as languages of instruction, neither language is now well-developed to facilitate effective learning, as will be discussed further in this study. I will elaborate more on language issues and their impacts on science learning in the following section, which outlines the background of the study.

[1] Before 1964, Tanzania mainland was named Tanganika. After the union of Tanganyika and Zanzibar in 1964 is when Tanzania was born by this union.

1.2 Background of the study

In what follows, I address the background for the present study. First, I introduce some views on the overall importance of science education. I then review the notion of learner-centred teaching, the major theme of my study. Then, I elaborate on the Tanzanian context in relation to learner-centred teaching, the practice of inquiry-based science teaching, students' motivations in science learning and the notion of contextual challenges. After that, I present the overarching aim of my thesis and the research questions. The last part of this chapter focusses on the definitions of key terms in my thesis.

1.2.1 Importance of science education

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2009), science education is an essential requirement of basic education, as it plays a crucial part in the world of work and the global economy. The current, developed world of science and technology requires, more than ever, people with competence in science and technology (UNESCO, 2009). According to the Next Generation Science Standards (NGSS (2013), science and engineering are crucial for addressing challenges in the modern world such as securing clean water, avoiding and curing diseases, ensuring availability of food and dealing with global environmental changes. Given that science and engineering are of foremost importance in the 21st century, the understanding of how scientific knowledge is acquired and applied is very important for students today (NGSS, 2013). To enable the use of science in solving the problems associated with our advancements in science and technology, all students need to be educated as critical consumers of scientific knowledge (Osborne & Dillon, 2008). This implies that students not only need to be recipients of scientific facts, but they need to be able to criticise new information and evaluate its relevance. Kolstø (2001) noted that knowledge about science will empower students in examining controversial issues. Exclusion from scientific literacy contributes to inequality in society and also limits people from influencing their environments (UNESCO, 2009).

The importance of science and technology is also highlighted in the Education and Training Policy of Tanzania (Sera ya Elimu na Mafunzo) by the Ministry of Education and Vocational Training (MoEVT), which reads:

> Elimu ya Sayansi na Teknolojia ni muhimu katika kumwezesha mwananchi kumudu mazingira yake na kumwezesha kuchangia maendeleo ya taifa

> (MoEVT, 2014, p. 29) (Education in Science and Technology is crucial for empowering citizens to adapt to their environment and contribute to national development.)

With this language, the policy emphasises the importance of science education. The quotation stresses the significance of science and technology for helping people to adapt to their surroundings. Also, the quotation emphasises that the national economy would benefit from science education. Taken together, these emphases prioritize scientific literacy for Tanzanian citizens. Learner-centred teaching is important for making learners interested in science (Osborne & Dillon, 2008), which is essential for learners' acquisition of critical thinking skills. Given the importance of science subjects for any society's well-being and development, my study focusses on education in science subjects, especially at the ordinary level of secondary education (lower secondary education). Learner-centred teaching is the main theme of my thesis and is addressed in the next section.

1.2.2 Learner-centred teaching

Learner-centred approach to teaching is a theme for various curriculum documents but lacks a common definition (Paris & Combs, 2006). This type of instruction emerged from constructivism, a philosophical approach in which learners are given first priority when educators are planning and executing teaching (Paris & Combs, 2006; Vavrus, Bartlett, & Salema, 2013). In this type of teaching students' ideas, opinions, needs and beliefs are respected and considered (Pierce & Kalkman, 2003). Some of the principles of learner-centred teaching from American Psychological Association APA (1997, pp. 3-5)) are listed in the coming quotes;

> The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.
> The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.
> The successful learner can link new information with existing knowledge in meaningful ways.
> Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.
> Learning is influenced by environmental factors, including culture, technology, and instructional practice.
> The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control (APA, 1997, pp. 3-4).

These principles of learner-centred teaching emphasise that learners are to be given an active role in creating knowledge. In such approaches, the learner is an active participant in learning. By connecting learners' experiences to the new information, meaningful learning is attained, which is an important aspect of learner-centred teaching. These principles from APA (1997) emphasise that, in learner-centred teaching, learners are monitoring their own learning and, in the process, acquiring creative and critical thinking skills. The principles also emphasise the importance of considering the context of the learner, such as his or her culture, for effective implementation of learner-centred teaching. In learner-centred teaching, students need to be actively involved in creating meaning through the use of inquiry-based teaching (Vavrus et al., 2013). This instructional type emphasises involving learners' prior knowledge, thinking and experiences to facilitate meaningful learning.

A report by UNESCO (2009) noted that an approach that makes the learner an active participant in learning is linked to intrinsic motivation and scientific literacy. Transmission approaches in the teaching can make learners less interested in science (Osborne & Dillon, 2008). Learners are encouraged in their science education when their experience, needs and prior knowledge are addressed in the classroom (Osborne & Dillon, 2008). Learner-centred teaching facilitates learner involvement in higher order thinking skills; this involvement is important in stimulating their intrinsic motivations (APA, 1997). The report by UNESCO (2009) notes that students are more interested in science when they are given chances to do investigations on their ideas and compare their findings with the extant body of scientific knowledge. To ensure that a large portion of the population acquires scientific literacy, thus promoting wider societal development, engaging learners in active learning in science seems important. Learner-centred teaching is the main theme for my thesis and, according to previous scholars (APA, 1997; Vavrus et al., 2013), this teaching style links the themes addressed in the three articles in my thesis: inquiry-based science teaching, critical thinking skills and intrinsic motivation. Further, learner-centred teaching is the focus of the operational Tanzanian ordinary level curriculum (MoEVT, 2005), as illustrated in the next section.

Learner-centred teaching in a Tanzanian context

Learner-centred approaches to teaching, following a constructivist philosophy, have been embraced by most educational policies implemented in Africa (Vavrus et al., 2013). These approaches emphasise, for example, the role that students' interactions play in their learning (Vavrus et al., 2013). The Tanzanian secondary education curriculum was changed from content-based and teacher-centred to competence-based and learner-centred (MoEVT, 2005). The curriculum emphasises the need for learners to take an active role in learning, as shown in the following quotation from the Tanzania curriculum;

> The implementation of Ordinary Level Secondary Education curriculum shall emphasize learner centred approach. That is the learner shall be placed at the focus of all the decisions that are made about the curriculum and how it will be delivered. This approach shall promote learning-through-doing where both the teacher and the student are active participants in the process. The teacher shall become a facilitator, motivator and a promoter of learning during the classroom interactions (MoEVT, 2005, p. 29).

This language from the curriculum emphasises the importance of learners being given priority in the decisions made in the curriculum and its implementation. The students are expected to take full responsibility for their own learning, while the teacher's role is minimised to that of a facilitator. The learner-centred curriculum of Tanzania requires teachers to design tasks that will involve learners in critical thinking, which is among the key competencies advocated by the curriculum. Critical thinking skills are expected to help learners understand, among other things, how knowledge is constructed, assessed and reformed in the different fields (MoEVT, 2005). Engaging learners in asking investigation questions, designing the investigations, conducting the investigations and drawing conclusions can make them understand how knowledge is constructed and assessed (Hattingh, Aldous, & Rogan, 2007).

According to the curriculum of Tanzania, teaching and learning methods suggested include the following: 'classroom based problem solving and enquiry', 'demonstration', 'posing problems as well as solving those set by the teacher', 'practice of technical or laboratory skills', 'debates', 'group discussions,' and 'analysing case studies' (MoEVT, 2005, p. 30). These teaching methods are learner-centred, as they require the learner's active participation in learning. Approaches like inquiry, problem solving and discussion can be useful in engaging learners in critical thinking skills, which is important in learner-centred teaching (APA, 1997). The learner-centred and competence-based teaching emphasis is also reflected in the syllabi for science subjects. For instance, what follows is a quotation from the Tanzanian ordinary level physics syllabus:

> By the end of the four years course, students should have developed competence in
> a. Using physics knowledge, principles and concepts in daily life;
> b. applying scientific methods in solving problems in daily life;

c. applying technological skills in conservation and sustainable use of the environment;
d. managing simple technological appliances;
e. using the language of physics in communication. (MoEVT, 2010b, p. V)

This quotation reflects the prioritised elements of critical thinking skills, such as application of science in daily life and problem solving. Also, the competencies reflect the elements of inquiry-based science teaching; for instance, in part b, learners are expected to be able to use scientific methods in solving problems in daily life, which implies that learners need to be able to develop questions for investigation, design investigations and collect and interpret data to come up with answers to the problems identified. All these competencies are connected to learner-centred teaching. In this section, I noted that the current ordinary level curriculum of Tanzania focusses on learner-centred teaching. The curriculum suggests that learners' voices be included during preparation of lessons and during teaching. Also, the general competencies suggested by the curriculum emphasise the engagement of learners in critical thinking skills. In my thesis, I studied learner-centred approaches to teaching which are linked to inquiry-based teaching (Vavrus et al., 2013), critical thinking skills (APA, 1997) and intrinsic motivation in learning science (Osborne & Dillon, 2008; UNESCO, 2009). In the next section, I provide the background for inquiry-based science teaching and for understanding students' motivations in science education in a Tanzanian context.

Inquiry-based teaching in science subjects in Tanzania

Inquiry-based teaching has a long history in Tanzania. The education for self-reliance introduced in 1967 had an element of inquiry-based teaching, which promotes learning by collaboration and experimentation (Vavrus et al., 2013). The education policy introduced in Tanzania by Nyerere, the first president of the United Republic of Tanzania, insisted that the type of education relevant for Tanzanian students is one which incorporates inquiry, as stated in the following paragraph:

> The Education provided must therefore encourage the development in each citizen of three things: an enquiring mind; an ability to learn from what others do and reject or adapt it to his own needs; and a basic confidence in his own position as a free and equal member of the society, who values others and is valued by them for what he does and not for what he obtains (Nyerere, 1968, p. 421)

This quotation from Nyerere (1968) highlights that the education provided in Tanzania should instill an enquiring mind for citizens. This implies that education should encourage learners to develop investigative skills or critical thinking skills; development of such skills requires learners to be more than only recipients of facts. Osaki (2007) describes several projects aimed at developing inquiry-based science teaching and students' acquisition of critical thinking skills during the introduction of Tanzania's education for self-reliance policy. The curriculum material was adapted from abroad, for instance in the School Science Project (SSP) and the School Mathematics Projects (SMP) (Osaki, 2007). The projects were tested in sample schools and involved activities such as bird watching, ecological investigations, report writing and outdoor activities, such as study tours. However, these trial science and math inquiry curriculums for education for self-reliance were abandoned in 1970 due to a lack of sufficient resources and a lack of well-trained teachers. Discontinuing the experimental inquiry curriculum during that time was also attributed to the failure of students who were trained in an inquiry curriculum but assessed by irrelevant, fact-based examinations (Osaki, 2007).

Even with the discontinuation of the experimental inquiry curriculum in 1970, the revised science curriculum of 1976 still emphasised students' engagement in scientific methods and problem solving (Ministry of National Education (MoNE, 1976)). The science curriculum of 1976 followed the notion of education for self-reliance, and inquiry-based teaching was among the curriculum agenda. Also among the teaching methods advocated by the curriculum, for example, in chemistry, was students' engagement in project work to study things in their surroundings (MoNE, 1976). Further, in physics, students were expected to do a field-trip to an interesting scientific location, and the guidelines encouraged experimental work (MoNE, 1976). Another curriculum review was done in 1997, following the recommendations resulting from monitoring and evaluations conducted by the Tanzania Institute of Education and other stakeholders. The revised curriculum also accommodated the views of heads of schools, examination councils and the larger Tanzanian society (MOEC, 1996). The revised, 1997 curriculum was content-based and put less emphasis on inquiry-based science teaching. For example, the objective of the chemistry course was students' acquisition of theoretical knowledge and application of that knowledge (MOEC, 1996). At this point, the emphasis shifted from inquiry science to content-based teaching. In content-based teaching, the focus was to ensure students' memorisation of facts and formula (Osaki, 2007).

Another curriculum revision, as indicated in the quotations from its material earlier in this section, took place in 2005. This revision was done to accommodate the global changes that require people with greater problem solving skills and creativity. The revised 2005 guidelines focus on promoting creativity and problem solving skills to prepare people who can appropriately use science and technology and contribute towards sustainable development of the country (MoEVT, 2005). In the 2005 ordinary level secondary education curriculum of Tanzania, inquiry-based teaching is highlighted. The curriculum follows a constructivist approach to teaching and learning. One of the objectives of education in Tanzania as stipulated in the MoEVT (2005) curriculum is ‘‘to develop and promote self-confidence and an inquiry mind’’(MoEVT, 2005, p. 12), which means students are expected to have investigative skills at the end of their secondary education. Likewise, among the teaching methods advocated by the competence-based curriculum is classroom-based problem solving and inquiry, and practical work has been given emphasis in all science subjects. What follows is a statement of general competence from the biology ordinary level syllabus emphasising practical work and some aspects of inquiry-based teaching:

> By the end of four-year course, the student should have ability to: 2. Record, analyze and interpret data from scientific investigations using appropriate methods and technology to generate relevant information in biological science. (2nd general subject competence in biology subject) (MoEVT, 2010a, p. iv)

According to this quotation, students are expected to attain practical skills such as abilities in collecting, analysing and interpreting data. This implies that students ought to apply practical skills that incorporate inquiry-based science teaching. Similarly, the chemistry syllabus emphasises practical work with elements of inquiry-based teaching, as can be seen in the following quotation:

> By the end of the four years course, the student should be able to:
> a) design and perform experiments;
> b) understand symbols, formulae and equations to communicate in chemistry;
> c) acquire Chemistry skills, knowledge and principles to solve daily life problems;
> d) appreciate application of scientific principles and knowledge in exploitation of natural resources with conservation of environment. (MoEVT, 2007, p. v)

The example of general objectives from a Tanzanian syllabus, above, emphasises practical work for higher levels of inquiry, which involve designing and conducting investigations. Also, other aspects of the general objectives recommend students’ engagements in critical thinking skills, like problem solving and applications of science. However, the specific objectives for the competence-based curriculum of the Tanzanian syllabi still focus on students’ attainment of scientific facts and not on investigative skills and critical thinking skills (Semali & Mehta, 2012; Wandela, 2014).

According to Njabili (1999) curriculum and syllabus are synonymous terms, but curriculum is the broader of the two. While there can be a syllabus for each specific subject, like chemistry, physics or biology, curriculum is a comprehensive plan that comprises all subjects that are to be taught at a certain level of education. For example, a curriculum for ordinary level secondary education is a plan for all subjects that are supposed to be taught at that level. The syllabus is the curriculum for a specific subject, like biology or physics, which indicates what is supposed to be taught in that particular subject. My observation in specific objectives of the science subjects' syllabi revealed that the specific objectives focus on the lower levels of inquiry and not on the higher levels of inquiry, such as posing problems and designing investigations. For example, Table 1.1, extracted from the chemistry syllabus, indicates that in the specific objective, the emphasis is on aspects of learning science like explanations and differentiation of scientific concepts rather than on the higher levels of inquiry.

Table 1.1. An example of specific objectives and strategies extracted from the chemistry ordinary level secondary education syllabus by MoEVT (2007 pg. 30)

TOPIC/SUB-TOPIC	SPECIFIC OBJECTIVES	TEACHING AND LEARNING STRATEGIES
2.1 The Concept of Hardness of Water	The student should be able to: a. explain the concept of hardness of water. b. differentiate soft from hard water.	The teacher to guide students to discuss the meaning of hardness of water. i) The teacher to lead students to perform an experiment to distinguish hard water from soft water by washing with soap. ii) Students to draw conclusion from their observations.

Table 1.1 indicates that the specific objective requires students to explain and distinguish scientific facts, which cannot capture the elements of critical thinking skills advocated by the general curriculum competencies. Although students' differentiating and explaining scientific facts is important in science learning, more integration of tasks that can engage learners into critical thinking skills, as suggested by the broad curriculum goals, is important. Likewise, the strategies suggest the teacher be the leader of the experiments, while students are supposed to draw conclusions from the experiment. This contradicts the role of the teacher as a facilitator, as advocated by learner-centred curriculum, instead suggesting the teacher as a more authoritative figure (a leader). At the same time, this indicates the contradiction between a broad curriculum goal and a specific objective in the syllabus. The broad curriculum goal suggests students be able to participate in experimental procedures, such as designing

investigations, problem solving and posing problems (MoEVT, 2005), but the specific objectives require students to work under the guidance of the teacher and draw conclusions, which are lower levels of inquiry-based science teaching aimed at students' acquisition of scientific facts. In this section, then, I noted the contradiction between broad curriculum goals and specific objectives. While in the broad curriculum, students are expected to be engaged in problem solving, conducting investigation and communicating their findings, the specific objectives put more emphasis on the lower levels of inquiry. Study of the actual practice of inquiry-based science teaching in the classroom and of the potential for its practice in schools in the Tanzanian context is important.

In this section, I review studies on the practice of practical work and inquiry-based teaching in Tanzania. Unfortunately, some studies report that practical work and inquiry-based teaching in Tanzanian contexts are not properly implemented (Mabula, 2012; Osaki, 2004; Semali & Mehta, 2012; Wandela, 2014). For instance, Osaki (2004) notes that science syllabi in Tanzania have huge amounts of content, and these syllabi indicate that practical work has to be conducted frequently; nevertheless, in practice, practical work is infrequently done. The study by Semali and Mehta (2012), which applied surveys, interviews, classroom observations and focus group discussions in Arusha, observed that, due to congested classes in the schools visited, the practice of experiments in schools was problematic. The study also noted that the science curriculum lacks sufficient emphasis on experimentation and critical investigation (Semali & Mehta, 2012). In a similar vein, a study by Mabula (2012), conducted in six districts in Morogoro, reported that practical aspects of science subjects were only theoretically learned.

Wandela (2014) offers one study which investigates the practice of inquiry-based teaching in Tanzania. The study was carried out in one school in Dar es Salaam, through the use of classroom observations of biology and chemistry practical work and lecture sessions. From the observations, the study noted that inquiry-based science pedagogy was not practised in the school. The focus in the teaching was on memorisation of facts, with few or no questions at all (Wandela, 2014). She also noted that the new science syllabi emphasises inquiry-based teaching; nevertheless, the teaching objectives in the syllabi and the examination questions in Tanzania still focus on scientific facts, which limit the practice of inquiry-based teaching (Wandela, 2014).

Some studies report that practical work in schools in Tanzania is not properly done as a result of inadequate resources: a lack of laboratories, chemicals and equipment; overcrowded classes; and a lack of science teachers (Mabula, 2012; Semali & Mehta, 2012). The use of a foreign language in teaching (Vavrus et al., 2013) and fact-based examinations (Vavrus et al., 2013; Wandela, 2014) in Tanzania were also factors which were mentioned as limiting inquiry-based teaching. According to Webb and Mkongo (2013), the use of English in teaching limits interactive approaches to teaching and students' acquisition of critical thinking skills. These studies from Tanzania indicate that inquiry-based science teaching is inadequately practised owing to the contextual challenges, such as language barriers, fact-based examinations and limited resources. Further research can enrich the previous findings, particularly study on the actual practice of and opportunities for inquiry-based science teaching in Tanzania. As I noted earlier in the review, intrinsic student interest in science, which is also studied in this, thesis is an element of successful learner-centred teaching. In the next section, I review the students' interests in science in Tanzania.

Interest in science in Tanzania

In this section, I review studies on interest in science in the Tanzanian context. A further, comprehensive review of interest in science world-wide will be presented in chapter two. A study in Tanzania indicates that students are not interested in studying science (Mabula, 2012); most students run to other fields. Further complicating the situation, a study has reported that teachers in schools are not motivated to teach science subjects (Semali & Mehta, 2012). According to the Ministry of Education and Vocational Training in Tanzania, only 30% to 35% of the students take science subjects in forms 3 and 4 (MoEVT, 2014). As an illustration, Table 1.2 indicates the number of students, in a school in Iringa Municipality in Tanzania, who registered for the national examinations in science elective subjects (chemistry and physics) during 6 years at form 4.

Table 1.2. Students registered for chemistry and physics for certificate of secondary education examination in a school in Iringa Municipality, Tanzania

Year	Total Number of students	Student enrolment in chemistry	Student enrolment in physics
2011	307	91 (30%)	53 (17%)
2012	194	80 (41%)	58 (28%)
2013	144	68 (47%)	62 (43%)
2014	127	57 (45%)	52 (41%)
2015	168	68 (40%)	61 (36%)
2016	135	56 (41%)	56 (41%)

Source: school recordson studentsenrolment in science elective subjects

The number of students who selected science (chemistry and physics) is especially not very low; nevertheless, the percent of students selecting science is below 50%. Overall, then, these numbers indicate no promising trend towards the attainment of science for all. In most cases, the number of students tends to be lower in physics than in chemistry.

There are some studies that have investigated the motivations of science students in Tanzania (Kinyota, 2013; Mabula, 2012; Ndalichako & Komba, 2014; Nyamba & Mwajombe, 2012). Kinyota (2013) wrote a master's thesis on students' perceptions of factors influencing the choice of science streams in Tanzanian secondary schools, using questionnaires, focus group discussions and interviews with 123 respondents. The study noted that the examination results, self-efficacy and external recompenses associated with science learning were the main factors for students' science choices. Another study investigating science interest in Tanzania is the study by Nyamba and Mwajombe (2012), who explored whether students' subject preferences affect their performances, using questionnaires for both teachers and students. The main factors which determine students' preferences, according to Nyamba and Mwajombe (2012), are availability of materials for experimentation, teachers' personalities (age, gender, how he/she relates to students), and students' levels of knowledge regarding the significance of science.

Ndalichako and Komba's (2014) mixed methods study observed students' subject preferences in Tanzania and explored the motives behind those preferences. The study reported that the majority of students in community secondary schools in Tanzania prefer arts subjects and not science subjects. According to Ndalichako and Komba (2014), students' subject preferences were affected by the scarcity of science teachers and laboratories. The study also noted that the use of English as the language of instruction plays a role in students' subject preferences by affecting students' understanding of the subject matter (Ndalichako & Komba, 2014). Mabula (2012) also did a study, in 4 districts in Morogoro, Tanzania, on science choice; the study applied questionnaires and focus group discussions with 471 students and 66 teachers. Mabula observed critical challenges which hinder students' choices in science, including insufficient resources and the scarcity of science teachers. In sum, most studies on students' motivations in science education in Tanzanian contexts focus on challenges for students' interests in science. These studies have indicated that some students in Tanzania are not interested in studying science subjects as a result of challenges such as limited resources and insufficiently trained science teachers. Little is known about the motivating factors for students who are learning science in the midst of such contextual challenges; this subject is addressed in this thesis. In the next section, I review various challenges that impact science teaching and learning in Tanzania.

Contextual challenges in science learning in the Tanzanian context

In this thesis, I refer to challenges that interfere with teaching and learning and that depend on economic, cultural and policy issues as contextual challenges. In the Tanzanian context, various factors have been identified as interfering with teaching and learning in schools. Previous studies show that the main contextual challenges are the language of instruction for subjects taught in secondary schools and the limited resources available.

Language of instruction.

Following the education and training policy of 1995, Swahili is the medium of instruction in pre-primary and primary schools, while in secondary and tertiary education English is used as the medium of instruction. After seven years of primary education in Swahili, students are expected to be able to use English for learning in secondary schools (MoEC, 1995). The new policy of 2014 advocates the use of both Swahili and English as languages of instruction at all levels of education (MoEVT, 2014), but the policy does not state clearly which language will constitute the main medium of instruction in secondary schools. Using English as a language of instruction has been problematic in Tanzania, since the use of English in teaching does not seem to enhance students' proficiency in English (Qorro, 2013). According to Wandela (2014), teaching in English in Tanzanian schools is a problem for both teachers and students. Neither teachers nor students are sufficiently competent in English to be able to use it as a language of instruction. Thus, using English as the teaching language is a barrier in the teaching and learning processes and is contributing to students' poor performances in science subjects (Mwinsheikhe, 2002). It also acts as a barrier for interactive teaching by discouraging students from asking and answering questions (Brock-Utne, 2000).

Limited resources.

Other contextual challenges involve inadequate resources, like laboratories, laboratory equipment, textbooks and science teachers. For example, a study by Mabula (2012), conducted in four districts in Morogoro (Tanzania), documented the shortage of science teachers in the schools; in some schools, there has not been a single science teacher employed at that moment. Ndalichako and Komba (2014) also reported the challenge of insufficient science teachers in the schools, and they noted that, in some schools, there were science subjects with no teachers. This is an indication that the challenge of inadequate numbers of science teachers in Tanzania is still persistent. Semali and Mehta (2012) reported further various challenges in science teaching, which include lack of laboratory equipment, overcrowded classrooms and lack of laboratories in some schools. Lack of textbooks, laboratory facilities and chemicals do influence students' subject preferences in Tanzania (Ndalichako & Komba, 2014).

In summary, learner-centred teaching is linked to inquiry-based science teaching, students' engagement in critical thinking skills and their intrinsic motivations in science (APA, 1997; Vavrus et al., 2013). This suggests that appropriate engagement of students in learner-centred teaching can engage students in inquiry-based science teaching and critical thinking skills, and, additionally, make them more intrinsically motivated in science learning. Studies in this section have outlined various contextual challenges in science teaching in Tanzania, such as limited resources, the use of an unfamiliar language of instruction and the limitations of facts-based examinations (Mabula, 2012; Ndalichako & Komba, 2014; Semali & Mehta, 2012). These challenges have been identified as a barrier for students' involvement in the learner-centred teaching that is advocated by the Tanzanian curriculum. The question of students' involvement in learner-centred teaching in a place with contextual challenges deserves investigation. Thus, this study focusses on the practice of inquiry-based teaching, students' engagement in critical thinking skills and their motivations in science education in community secondary schools in Tanzania.

1.3 Statement of the problem

Scientific literacy is important for the well-being and development of any society. An appropriate scientific literacy is one that makes students critical consumers of scientific knowledge and not merely recipients of scientific facts (see section 1.1). Nevertheless, studies in the Tanzanian context (Mabula, 2012; Ndalichako & Komba, 2014) have revealed that students are losing interest in science. Lack of student interest in science may act as a barrier for students in learning basic scientific concepts relevant to their life, hence limiting scientific literacy in the population as a whole. Challenges such as lack of facilities in schools (Ndalichako & Komba, 2014), low motivation of teachers (Semali & Mehta, 2012), poor quality and shortages of science teachers, and incompetence in the language of instruction (Ndalichako & Komba, 2014) have been mentioned among the factors that limit students' interests in science.

That there are contextual challenges that constrain science teaching and learning in the Tanzanian context is well established. The learner-centred curriculum of Tanzania focusses on students' attainment of critical thinking skills (MoEVT, 2005), skills which can be attained through inquiry-based science teaching. The research on how learner-centred teaching can be attained in the presence of Tanzania's contextual challenges is the motivation behind this investigation. Little is offered in the extant science education research with regard to what needs to be done at the levels of policy, curriculum and classrooms to make the practice of inquiry-based teaching and student engagement in critical thinking skills a reality in schools facing serious contextual challenges. Also, little is known with regard to what motivates students to study science subjects in schools with contextual challenges such as limited resources, lack of fluency in the language of instruction and congested classes. These are the knowledge gaps my study addresses. My study was conducted in 6 community secondary schools in Iringa municipality in Tanzania, each with various contextual challenges.

1.3.1 *Research questions*

1. What role do contextual factors play in the practice of inquiry-based science teaching, specifically in the Tanzanian context?

2. What are the potentials for inquiry-based teaching in community secondary schools in Tanzania?
3. What motivates students when they are learning science in schools with contextual challenges?

1.4 Definitions of key terms

In my thesis, the main terms are learner-centred teaching, inquiry-based science teaching, motivation and interest in science and contextual challenges.

1.4.1 Learner-centred teaching

Learner-centred teaching is a pedagogical approach to teaching where students' ideas and opinions are valued, students are involved in critical thinking skills, and students needs and beliefs are considered (Pierce & Kalkman, 2003). In this approach to teaching, the learners are the main focus in teaching and their backgrounds, interests and capabilities direct the teaching process (Vavrus et al., 2013). Learner-centred teaching is the main theme for my thesis and is addressed in all three articles. I define learner-centred teaching as the teaching approach in which the learner is given first priority in the curriculum content and in the learning activities in the classroom. Inspired by previous scholars (APA, 1997; Vavrus et al., 2013), when learners are involved in inquiry-based teaching and critical thinking skills and their needs and interests are considered in planning and executing teaching, I consider their education to represent learner-centred teaching, in my study.

1.4.2 Inquiry-based science teaching

For my present study, the definition of inquiry-based teaching is inspired by other studies (Crawford, 2014; Jiang & McComas, 2015). Inquiry-based teaching, in this thesis, involves students' involvement in asking investigation questions, designing an investigation, conducting the investigation, drawing conclusions from the investigation, and communicating the findings.

1.4.3 Motivation and interest in science

Various scholars have different definitions of interest in science. In some studies the terms 'interest in science', 'motivation in science' and 'attitudes towards science' have been used interchangeably. For instance, Potvin and Hasni (2014) observed that, in their review, the major constructs that were used for interest in science included interest, motivation and attitudes. According to Tytler and Osborne (2012), attitudes towards science as a concept include positive attitudes towards science, enjoyment of science learning, curiosity in science and its learning practices, and interests in working in scientific jobs. Learners' enjoyment or interest in science, including learning activities and practices in science lessons, is linked to their motivations, interests and attitudes towards science. Thus, in my thesis, interest in science is considered as motivation in science, which may be indicated by liking or disliking science subjects and learning experiences in the subjects.

1.4.4 Contextual challenges

Contextual challenges in my thesis refer to challenges which limit teaching and learning in a context and which are related to the economy, the culture and the policies of that particular context. These challenges include policy factors (e.g. language of instruction), curriculum factors (e.g. content of the subject matter), and school factors and classroom factors (e.g. limited resources, classroom culture).

2.0 Overview of Previous Studies and Knowledge Gap

The main purpose of this chapter is to review what is known in my area of study and identify the knowledge gap. In connecting my research with the previous studies, I highlight the relevance of my thesis in addressing the knowledge gap identified in the literatures. Some review of research in the Tanzanian context was offered in chapter one. The focus of the review in this section instead encompasses international perspectives. The themes of the literature research and presentation were guided by my research questions, which focus on inquiry-based science teaching and students' interests in science.

2.1 Practical work and inquiry-based teaching in science subjects

Practical work and inquiry-based teaching are important for maintaining students' interests in science (Crawford, 2014; Jiang & McComas, 2015). Jiang and McComas (2015) note that inquiry-based teaching, particularly involving learners in asking investigation questions and designing investigations, are important in improving students' interests in science.

According to Osborne and Dillon (2008), all learners need to be educated as critical consumers of scientific knowledge. In that way, they can address the modern challenges resulting from the development of science and technology (Crawford, 2014; Osborne & Dillon, 2008). For learners to be critical consumers of scientific knowledge, they need an understanding of the practice of inquiry (Crawford, 2014). Hofstein and Lunetta (1982) note that open-ended practical work that engages students in problem solving can facilitate learners' development of creative thinking. There is a link between inquiry-based science teaching and students' engagement in critical thinking skills (Hofstein & Kind, 2012; Kipnis & Hofstein, 2008). Engaging learners in critical thinking skills can make them attain meaningful learning and apply what they have learned in various contexts (Hofstein & Kind, 2012). Including students in developing questions for investigation, designing their investigations and drawing conclusion from their investigations can engage them in critical thinking skills (Kipnis & Hofstein, 2008). This implies that inquiry-based teaching can facilitate meaningful learning and students' engagement in critical thinking skills.

Practical work and inquiry-based teaching can help students understand the nature of science (Hofstein & Lunetta, 2004). This implies that students should learn how scientific knowledge is acquired through practical work. According to Hattingh et al. (2007), a low level of practical work, like guided experimentations and demonstrations, facilitates learners in understanding how current scientific knowledge is confirmed, while a higher level of practical work, like asking questions for investigations and designing investigations, enables the learner to understand how new scientific knowledge is acquired and verified. But there are factors that limit inquiry-based science teaching

According to Hofstein and Kind (2012), practical work and inquiry-based teaching in most classrooms are not appropriately done, and the focus is more on recipe-type activities. When students are only engaged in a recipe-based activity, without being engaged in the stages of inquiry, attaining meaningful learning is difficult; mostly, students in these activities are engaged only in the memorisation of facts (Abrahams & Millar, 2008), which cannot sufficiently engage learners in critical thinking skills. Involving students in discussion of an inquiry-based task can engage them in critical thinking skills. A study by Abrahams and Millar (2008) was conducted in 25 lessons in the UK schools. Data were collected by the use of field notes and interviews with the teachers. The study observed that there was almost no discussion in any of the observed lessons about scientific inquiry. Teachers focussed overly much on ensuring that students did what the teacher intended them to do, following the guidelines given (Abrahams & Millar, 2008). The study further reported that there was no ample time given for students to develop links between observations and ideas during practical work. The aspect of inquiry, such as discussion on the collection, analysis and interpretation of the results, was neglected. This is an indication that students' involvement in inquiry-based science teaching is not effective even in schools in Europe, in which physical resources in science teaching cannot be as scarce as in some schools in African contexts. From this observation, I can argue, as do Hattingh et al. (2007), that physical resource availability is not the most important aspect for inquiry-based science teaching.

In African contexts, as well, studies have reported that the practice of practical work and inquiry-based teaching is limited (Hattingh et al., 2007; Kapenda, Kandjeo-Marenga, Kasandra, & Lubben, 2002). For instance, the survey study by Hattingh et al. (2007) in South Africa observed that lower level practical work, such as teachers' demonstrations and recipe-based practical work, was more frequently offered than were higher levels of practical work, such as designing investigations. Another study was conducted in Namibia by Kapenda et al. (2002), in which data were collected by the use of several methods including review of lesson plans, students' worksheets and students' work, as well as classroom observations. The study reported that a quarter of the teachers in the sample did not provide any practical work to students, while other teachers offered little practical work. Key aspects of inquiry, such as drawing conclusions and making generalisations from experimental findings, were not given much emphasis (Kapenda et al., 2002). These studies, from an African context, indicate that, in some schools in Africa, even recipe-based kinds of practical work are not done. Students are learning science mainly theoretically through lecture methods (Semali & Mehta, 2012), which can not sufficiently result in meaningful learning .

In particular, hindrances for the appropriate practice of practical work and inquiry-based science teaching involve limited resources (Crawford, 2014), teachers' knowledge and perceptions (Crawford, 2007), students' abilities and languages of instruction (Hattingh et al., 2007). The review by Crawford (2014) notes that inadequate space and materials, limited time, overcrowded classes and students' abilities are limiting factors for the practice of inquiry-based teaching. A mixed method study by Ramnarain (2014), done in schools in South Africa, noted that a lack of resources and the prevalence of congested classes in township and rural schools make the implementation of inquiry-based teaching difficult. Inadequate resources, time limits, overfull classes and expectations that large amounts of content will be covered are not under the control of teachers. Teachers who are working under pressure and with limited resources to cover large amounts of content needed for students to answer their examinations can hardly engage students in inquiry-based teaching. Teachers' perceptions were also reported to be among factors that limit the practice of inquiry-based teaching (Crawford, 2007; Hattingh et al., 2007). For example, Hattingh et al. (2007) noted that the factor that most determines the quality of practical work in science classrooms is teacher perception regarding learners' abilities, motivations and proficiency in the language of instruction. Teachers can be discouraged from using inquiry-based science teaching when the strategy seems unfruitful considering the level of students' understanding. According to Crawford (2007), the factor that most influenced the prospective teachers' practice of inquiry-based teaching was teachers' beliefs regarding pedagogy, students' learning and the nature of scientific inquiry. Thus, teachers' understandings of the nature of science can be important factors for students' engagement in inquiry-based science teaching. From this review, however, not much is known regarding the actual practice of inquiry-based teaching and the approaches which can facilitate such practice in schools with contextual challenges such as inadequate resources, large classes and problems posed by an unfamiliar language of instruction.

To sum up, the review in this section revealed that inquiry-based teaching and practical work are not sufficiently implemented in various part of the world. Factors such as limited resources, overfilled classrooms, limited time, teachers' perceptions, unrealistic content coverage expectations, fact-based examinations and the use of a foreign language as the language of instruction were mentioned as limiting inquiry-based teaching and practical work. According to studies reviewed in this section, in African countries, the practice of practical work and inquiry-based teaching is less often conducted, compared to other parts of the world. Still, little is known regarding the practice of practical work and inquiry-based teaching under the contextual challenges identified in this section, which is the first research question for my thesis. In a Tanzanian context, moreover, there is limited research with regards to the potentials of inquiry-based teaching in schools, which guides the second research question for my thesis.

2.2 An overview of students' interests in science subjects

The review in this section is based on students' interests in science in various parts of the world, factors influencing interests in science and contextual factors that influence interests in science. Before proceeding further with this discussion, I wish to highlight the meaning of 'interest in science' as approached by the studies discussed in this section. Potvin and Hasni (2014) noted that studies use motivation, interest and attitude as their main constructs in studying interest in science. In measuring attitudes towards science, different aspects and terms have been utilised, including, among others, motivation towards science, enjoyment of science, the value of science and interest in science and scientific tasks (Tytler & Osborne, 2012). Attitudes towards science refers to feelings an individual has regarding science in schools and the role of science in the larger society (Osborne, Simon, & Collins, 2003). In assessing students' interests in science, The Relevance Of Science Education[2] (ROSE) project survey uses an interest inventory. Various scientific concepts were presented in a questionnaire for students to indicate their interests for various areas of science. These studies have highlighted the link between interests, attitudes and motivations in science.

Several recent studies have reported a decline of interest in science among students (Potvin & Hasni, 2014; Sjøberg & Schreiner, 2010; Tytler & Osborne, 2012). For instance, a review by Tytler and Osborne (2012) noted that students' attitudes towards science decline as students

[2] ROSE is an international study exploring young learners' interests in science and technology. The study explores factors affecting students' motivations in science and technology interest, such as out of school experiences, interests in science topics in various contexts, interests for scientific jobs and views of science in the larger society (Sjøberg & Schreiner, 2010).

move from one level to the next in elementary school. Reviews also report that the decline of students' interests in science is more acute in developed than developing countries (Potvin & Hasni, 2014; Tytler & Osborne, 2012). An international ROSE survey explored the factors that affect students' motives in learning science and technology (Sjøberg & Schreiner, 2010). The overview findings from the ROSE project have also revealed this contextual difference in interest in science. One of the findings was that students from developing countries showed more interest in science than students from developed countries (Sjøberg & Schreiner, 2010). Studies have also revealed a gender difference in interests in science (Sjøberg & Schreiner, 2010); boys were indicated to have more interest than girls (Osborne et al., 2003; Sjøberg & Schreiner, 2010; Tytler & Osborne, 2012). However, this trend is subject-specific; while boys indicated more interest in physics and technology than girls, biology is preferred more by girls than boys (Potvin & Hasni, 2014; Sarwar, Naz, & Noreen, 2011). This contextual difference in interests in science calls for further exploration, as studies conducted in developing countries note, in apparent contrast, that students in these contexts have less desire to study science owing to the various challenges they face (Mabula, 2012; Ndalichako & Komba, 2014). Taken together, these results offer an indication that students can have positive interests in science but decide not to study the subject because of the contextual challenges. My study in Article III addresses this gap by exploring the sources of students' motivations in science learning in schools with contextual challenges.

International comparative studies on students' interests in science have shown varied results. For instance, a survey by Iqbal, Nageen and Pell (2008), which compared English and Pakistani students' interests in becoming scientists, observed that Pakistani students show more desire to become scientists than English students, despite the difficult learning environment in Pakistan. Similarly, the study noted no gender differences for Pakistani students' interests in science. Another survey by Wang and Berlin (2010), conducted in Taiwan, observed no differences in interests in science as students moved from one level to another. The study also noted no gender differences in interests in science. A review by Sarwar et al. (2011), which explored the effect of nationality on interests in science, concurs with other studies that students from developing countries are more interested in science than those from developed countries. Nevertheless, the study noted that the overall interest of students towards science was positive, globally, which contradicts other findings which have indicated deterioration of students' interests in science. Such inconsistent findings call for more investigation. Adding to the debate, my thesis explores the motivation of students towards science education under contextual challenges, which is addressed by Article III. Having discussed interests in science in various parts of the world, I will next explore factors that affect students' interests in science, based on previous studies.

Science teachers and their teaching approaches are significant factors which affect the interests of students in science (Osborne et al., 2003; Potvin & Hasni, 2014; Tytler & Osborne, 2012). According to Potvin and Hasni (2014), teachers who have good relationships with students and encourage them in learning play important roles for their students' motivations in science. The review by Osborne et al. (2003) reported that the kind of teaching where the teacher loves the subject, connects the subject to the context and provides fascinating lessons can facilitate students' science choices and interests. The review also noted that the teacher being friendly with students and advising them on their career choices are among the characteristics of good teaching (Osborne et al., 2003). Tytler and Osborne (2012) argued that the traditional way of teaching, dominated mainly by transmission approaches such as note-taking, discourages students from persisting in science learning. A video study by Anderhag, Hamza, and Wickman (2015) observed that teachers supported students' interests in science by making follow-up plans and recognising students' inputs in the classroom.

Another factor which plays a role in students' science interests is the practice of inquiry-based teaching (Crawford, 2014; Potvin & Hasni, 2014). Inquiry-based teaching can be utilised as a way to ensure that youth are interested in science (Crawford, 2014). According to Jiang and McComas (2015), students' involvement in higher levels of inquiry, such as asking questions for investigation and designing the investigation procedures, contributes to more interest in science. Also, a focus group study by Osborne and Collins (2001) reported that one thing that makes students find science uninteresting is the lack of discussion. Discussion and practical work make the learners creative, and they assume more ownership of their learning, hence making science more interesting to them (Osborne & Collins, 2001).

Another factor which influences students' attitudes towards science is the curriculum variable. Studies have indicated that science curricula which relates to students' interests and experiences will likely foster positive attitudes towards science (Barmby, Kind, & Jones, 2008; Christidou, 2011; Koballa & Glynn, 2007; Osborne et al., 2003). For instance, Osborne and Collins (2001), in their qualitative study on attitudes of students towards science subjects, found out that various aspects of school science curriculum were not interesting to students;

for instance, in chemistry the periodic table, as well as a theoretical emphasis on microscopic substances such as electrons, was perceived as irrelevant (Osborne & Collins, 2001). In contrast, aspects of science which were relevant to the students were also interesting to them; for example, students expressed interest in human biology, practical work in mixing chemicals, forces in relation to cars and airplanes, and light and electricity (Osborne & Collins, 2001). In a similar way, Potvin and Hasni (2014) noted that a curriculum design focussed on aspects which are relevant and useful to the daily life of the learner contributes to a student's intrinsic motivation in science.

Additionally, the perceived difficulty of science has been mentioned as impacting students' interests in science. According to Osborne et al. (2003), Potvin and Hasni (2014), and Tytler and Osborne (2012), the way students perceive science subjects as difficult subjects affects their interests in these subjects. Tytler and Osborne (2012) also noted that the perceived abilities of students in science are influenced by socioeconomic status. They further argued that parental status, such as parents' educations and careers, plays a role for students' expectations and their beliefs in their abilities (Tytler & Osborne, 2012). Osborne and Collins (2001) note that the aspects in science that students perceive to be difficult are described by students as uninteresting, which indicates that the difficulty of a topic makes it uninteresting to students. According to Osborne et al. (2003), those who enroll in science are those who perform well in examinations, which has led to the mistaken impression, among students, that science is for gifted kids only. Having reviewed, then, the various factors that influence students' interests in science, next I will discuss some contextual factors that affect science learning in sub-Saharan Africa, particularly.

2.3 Contextual factors that affect science learning in Sub-Saharan Africa

Partly, my study focusses on motivational factors for students' science learning in schools with contextual challenges. Thus, I deemed a review of the contextual challenges for science learning particular to sub-Saharan Africa relevant, in order to highlight this aspect of my study. Studies from sub-Saharan Africa have revealed various contextual challenges that limit science learning. For instance, a study conducted in six African countries involved in the Trends in International Mathematics and Science Study (TIMSS) reported that all participating African countries had lower performances than the international country mean in TIMSS 2003 (A Asabere-Ameyaw & Mereku, 2009). The poor performances in those schools was associated with challenges such as insufficiently trained teachers, science content that did not meet students' learning needs and lack of use of technology in science learning (A Asabere-Ameyaw & Mereku, 2009). Although I focus in students' interests in science, I consider highlighting the issue of students' performances important, because there is a link between interest and performance in science (Osborne et al., 2003; Potvin & Hasni, 2014; Tytler & Osborne, 2012). Students are rarely interested in learning a subject that they associate with poor performances or negative academic consequences. According to Ottevanger, Van den Akker, and de Feiter (2007), a number of challenges in science education, such as poorly resourced schools, overcrowded classes, irrelevant curriculum, insufficient qualified teachers and limited equipment for experimentation, were observed in 10 sub-Saharan countries. Their study further noted that oversized content expectations and irrelevant curriculum contributed to poor performances of students in science subjects (Ottevanger et al., 2007). Poor performances from students in developing countries in Africa have also been associated with poor learning environments in schools (Dzama & Osborne, 1999).

In African contexts, students have shown low self-esteem in connection with science education, believing that the subject is difficult and that they cannot manage it (Anamuah-Mensah, 2012). Also, science as taught in these schools is not well linked to everyday life; thus, it cannot appropriately enable learners to solve contemporary challenges in their societies (Anamuah-Mensah, 2012). When science is not linked to the contemporary daily life of the learner, science education cannot adequately facilitate the meaningful learning (Scott, Mortimer, & Ametller, 2011) that is important for students' intrinsic motivations. Science curriculum developers have not yet been able to develop a curriculum which can accommodate both local scientific knowledge and scientific knowledge in the classroom (Osaki, 2004). This gap makes learners in science classrooms see the subject as an entity detached from their real world and which can not sufficiently engage them in meaningful learning. What seems to have been given less emphasis in the literature is what motivates students when they do learn science in a setting with contextual challenges, confronting inadequate resources, overcrowded classes and insufficient fluency in the language of instruction. This is addressed by the third research question of this thesis. As noted in science education research around the world, and in sub-Saharan Africa specifically, general scientific literacy is increasingly important, and the need to educate future scientists remains (Ottevanger et al., 2007). Ensuring that students are interested in studying science is important so that they acquire scientific literacy. Therefore, the issue of students' interests in science deserves investigation.

3.0 Theoretical Frameworks

This chapter's focus is on the theoretical lenses and notions that I drew upon when exploring learner-centred teaching in community secondary schools in Tanzania. I selected these theoretical lenses and notions based on their relevance to the topic I studied and the data material I utilised. The main theoretical lenses and ideas used in my thesis were the social constructivist view of learning, practical work and inquiry-based science teaching, critical thinking skills, scientific literacy and intrinsic motivation in science.

3.1 Social constructivist view of learning

Driver, Asoko, Leach, Scott, and Mortimer (1994) noted that using the notion of social constructivism in science learning implies that scientific knowledge is socially created and confirmed. In science learning, the learner is introduced to scientific ways of 'knowing'. Learning in schools is not a totally new experience to students; rather, it awakens previous experiences and the learners' prior knowledge (Vygotsky, 1978). In the science lessons, learners are coming in with their own understandings of science from everyday perspectives which need to be mediated to a consensus, scientific way of knowing with the help of the teacher (Driver et al., 1994; Vygotsky, 1978). Learning experiences in schools need to allow the learner to assimilate their prior knowledge to their experiences in the classroom for meaningful learning. Vygotsky (1978) proposed the notion of the Zone of Proximal Development (ZPD) as an important feature of learning. ZPD is defined as the distance between what a child can perform alone, without any assistance, and the maximum performance of a child under guidance (Vygotsky, 1978). According to Vygotsky (1978), the mediation of a learner's prior knowledge and new ways of knowing requires support from the teacher, the learner's peers and the environment. Learners need teachers' guidance and interaction with others and their surroundings to facilitate meaningful learning. Learning contexts such as the use of home materials can facilitate the creation of a third space that is useful in integrating science from the classroom with students' experiences outside the classroom (Ramnarain & de Beer, 2013) to support meaningful learning. In my thesis, the notions of social constructivism, specifically the aspects of students' attainment of meaningful learning upon integrating their experiences to scientific knowledge in the classroom, supported by the teacher and the classroom setting, has been applied in various ways. In Article II, I studied students' engagement in meaningful learning through questions asked in the sessions and through various learning approaches. Questioning approaches that allow learners to bring their prior knowledge, thinking and experiences were considered useful for meaningful learning. Similarly, in Articles I, II and III, teaching approaches such as the use of locally available materials for students' investigations were considered useful in creating a third space which makes joined knowledge from home and school meaningful and useful.

3.2 Practical work and inquiry-based teaching

The notion of inquiry-based science teaching has a long history in science education; over one hundred years has passed since Dewey suggested inquiry-based teaching as foundational in science teaching (Crawford, 2014). Criticizing the traditional transmission approach to science teaching, Dewey (1910) noted that science teaching at the time was emphasising transmission of scientific knowledge as facts or laws and not as a technique of inquiry. According to Dewey (1910) the traditional laboratory work where students just manipulate materials according to set rules is similar to textbook and lecture instruction, as it cannot change the students' minds. This implies that laboratory work which does not involve inquiry cannot support students' critical thinking skills; thus, it becomes similar to a transmission approach to teaching. In emphasising inquiry-based teaching, Dewey (1910) noted that an individual will be educated in science if he/she can acquire a way of thinking and be able to search for evidence for a claim or belief.

There is no agreed upon definition of practical work among scholars in science education (Dillon, 2008). According to Hofstein and Kind (2012) practical work is similar to laboratory work and the term implies experiences in schools in which students actively engage with materials or secondary data sources so as to observe and develop understanding of the natural world. The other definition of practical work which relates to laboratory activity is by Hofstein and Lunetta (2004), who define laboratory activity as a learning experience in which students are engaged with objects and representations so as to appreciate the natural world. Abrahams, Reiss, and Sharpe (2013) defined practical work as a science activity which involves students, either in groups or individually, in operating and observing real materials. The definition of practical work in my thesis is students' active involvement with sources of data so as to understand the phenomenon they are studying; this definition is in-line with the definitions of previous scholars (Abrahams et al., 2013; Dillon, 2008; Hofstein & Kind, 2012; Hofstein & Lunetta, 2004).

Like practical work, inquiry-based teaching has various definitions among scholars in science education. According to Crawford (2014), inquiry-based teaching is taking place when students are involved in asking questions about a certain scientific phenomenon, designing and doing investigations, and explaining and discussing their findings. Inquiry-based teaching can not only involve a hands-on activity, following written guidance in order to verify known results, without reflecting on the activity within the context of the real world (Crawford, 2014). Jiang and McComas's (2015) framework for inquiry-based teaching has four components: students are actively participating in conducting activities, drawing conclusions from the data, designing the experiments and raising questions for investigation. In identifying the levels of openness of inquiry-based science teaching in Article I, I utilised the framework proposed by Jiang and McComas (2015), in which the level of openness of inquiry increases when students are taking an active role in inquiry components, from conducting the activities to raising questions for investigation.

Studies suggest that practical work can involve inquiry-based teaching (Abrahams & Millar, 2008; Hofstein & Kind, 2012; Hofstein & Lunetta, 2004). However, some practical work may not involve inquiry-based teaching, and inquiry-based teaching may be practised even without hands-on activities (Crawford, 2014). Thus, even though there might be a link between practical work and inquiry-based teaching, the two terms are not synonymous. Practical work has various roles in science teaching, including, among others, making students understand science concepts, developing students' understandings of the nature of science, teaching students manipulative skills and connecting science to daily experiences for students (Hofstein & Lunetta, 2004). This set of roles implies that practical work may be designed for other purposes than for inquiry-based teaching. When students are involved in making and evaluating explanations in scientific discussions, students are involved in inquiry-based teaching (Crawford, 2014). Critical thinking skills are linked to inquiry-based teaching and involve the ability to use the scientific knowledge attained in other, various situations (Hofstein & Kind, 2012). A previous study from Tanzania notes that inquiry-based science teaching is difficult to practise (Wandela, 2014). Thus, in my thesis, I focus on opportunities for inquiry-based science teaching. Critical thinking skills are linked to inquiry-based science teaching (Hofstein & Kind, 2012); therefore, in this thesis, approaches in science lessons that involve learners in critical thinking skills, such as asking questions for clarification, backing claims with evidence and asking for evidence for others' claims, demonstrating open-mindedness, applying scientific knowledge, drawing conclusions from available facts and problem solving are considered potentials for inquiry-based science teaching.

Hofstein and Lunetta (1982) noted that one of the goals of laboratory instruction is to develop practical skills, such as designing and conducting investigations, collecting data, and analysing and interpreting the results. They further noted that laboratory activities can enhance students' creative thinking, problem solving and inquiry abilities (Hofstein & Lunetta, 1982). According to Abrahams and Millar (2008), carrying out recipe-based experiments without being involved in the different stages of inquiry promotes students' memorisation of facts and procedures and is not helpful in enabling them to connect the experiments with larger scientific ideas. Helping students to know how scientific knowledge is acquired and utilised can be another aim of practical work (Hofstein & Kind, 2012), particularly when the practical work is designed to engage students in inquiry-based science teaching. This implies that, in doing laboratory work or practical work, students can learn about the nature of science through inquiry-based teaching. In practical work designed for inquiry-based teaching, students learn to investigate, to establish claims, and to defend those claims by comparing their evidence with that of the scientific community (Hofstein & Lunetta, 2004). In my thesis, practical work can incorporate different levels of inquiry-based teaching. Practical work in which the teacher is doing all the activities, like preparing the investigation questions, designing the investigation procedures, doing the investigation and drawing conclusions from the investigation without involving the learners, is not considered inquiry-based teaching. On the other hand, a practical activity that involves students in all or some of the elements of inquiry-based science teaching, as listed above, is considered inquiry-based teaching. This concept is applied in this thesis in answering the first research question. When investigating the role of contextual challenges in practicing inquiry-based science teaching, teachers' responses and observational notes were compared to the frameworks for inquiry-based science teaching.

3.3 Critical thinking skills

In this section, I review the place of critical thinking skills in science education and the term's meaning. Thereafter, I review elements of classroom settings and activities that can foster or inhibit critical thinking skills. Lastly, I elaborate on the use, in my thesis, of the notion discussed.

Scientific knowledge should not be conceived of as the accumulation of facts that need to be transmitted to students, devoid of engagement, but instead as closer to shaping new patterns and strategies in students' thinking (Kuhn, 1993). Students in science learning need to integrate their thinking and their understanding. The notion that scientific knowledge is subject to change upon the emergence of new evidence is thought to foster the development of critical thinking skills in students (Siegel, 1989). In science learning, students need to understand that what they learn is only true with regards to the currently available evidence and all knowledge can be revised if contradictory evidence emerges. Instilling critical thinking skills in students is, thus, an important aspect of science education.

According to Kuhn (1993), critical thinking skills represent the ability of an individual to distance themselves from their own thinking and experiences so as to be able to evaluate those experiences without bias. This indicates that, in critical thinking skills, individuals need open-mindedness, so that they can look at all possible explanations without bias. An individual with a critical thinking attitude is a searcher of evidences and explanations for the beliefs in all situations, including contexts where her own beliefs and experiences are challenged (Siegel, 1989). In an investigation, critical thinkers will be able to collect all kinds of evidence, not only those that concur with their beliefs or expectations. A critical thinker is capable of evaluating reasons to see whether they satisfactorily support connected beliefs, claims and actions (Siegel, 1989). When students participate in inquiry activities, such as developing hypotheses about a problem, collecting data, analysing data and drawing conclusions, they are involved in aspects of critical thinking skills (Kipnis & Hofstein, 2008; Mathews & Lowe, 2011).

In critical thinking, an individual explores a question or a problem to come up with a conclusion or hypothesis supported with evidence (Kurfiss, 1988). This implies that critical thinking can involve problem solving and drawing conclusions. Also, for a critical thinker, any conclusion or hypothesis needs to be backed with evidence (Kurfiss, 1988). Asking for evidence for a claim and backing up any conclusions with the relevant evidence are both elements of critical thinking skills. A review by Lai (2011) highlighted several common elements of critical thinking skills from psychological, philosophical and educational schools of thoughts, including drawing conclusions by applying inductive or deductive reasoning, performing evaluations, problem solving and asking and answering questions for clarification. When students are doing investigations and coming up with conclusions based on their evidence, they are engaged in critical thinking skills. Also, engaging in questions that involve students' thinking and reasoning abilities can be considered as an element of critical thinking skills. Critical thinking kinds of problem solving involve questions with no single, pre-determined answer (Kurfiss, 1988). In such problem solving, students can come up with various answers according to their thinking, experiences and investigations. According to Miri, David, and Uri (2007), when students were involved in real world problem solving, open-ended discussions and inquiry-based activities, they showed a disposition to employ useful critical thinking skills, such as maturity, truth-seeking and open-mindedness. When dealing with problems linked to their daily experiences, students can be involved in critical thinking skills such as problem solving and open-mindedness.

Inspired by different scholars (Bissell & Lemons, 2006; Kurfiss, 1988; Lai, 2011; Miri et al., 2007), I have identified seven elements of critical thinking skills, and I utilise them as a framework in my thesis; these are:

- asking questions for clarification;
- backing up claims with evidence;
- asking for evidence for claims;
- open-mindedness;
- application of scientific knowledge;
- drawing conclusions from available facts;
- and problem solving.

I found these elements from previous studies to be relevant to the higher level skills identified in the data material used for the first and second articles. These elements are also relevant in identifying critical thinking skills in my data material because they were previously identified by several other studies as linked to critical thinking skills (Bissell & Lemons, 2006; Kurfiss, 1988; Lai, 2011; Miri et al., 2007). In my study, I consider that students were engaged in critical thinking skills if one or more of these elements were observed during instruction. This critical thinking skills notion has been applied in answering the first and second research questions in two articles of my thesis. In the articles, I have identified levels of openness of inquiry-based teaching, such as involving students in developing questions for investigation, designing investigations, conducting investigations and drawing conclusions, which are all linked to students' attainment of critical thinking skills (Kipnis & Hofstein, 2008). In the second article, the video data were coded using the elements of critical thinking skills outlined in our framework, above. In a learning context, both specific activities performed and the classroom environment can contribute to students' engagement in critical thinking skills.

Kipnis and Hofstein (2008) observed that, when students are doing inquiry laboratory activities, they practise metacognition skills of various types at every stage of their investigation. Questions asked in the classroom can influence the practice of metacognition skills. Open-ended and higher level questions can be useful for students' development of critical thinking skills (Mathews & Lowe, 2011). The use of strategies such as engaging higher level questions and giving students roles that reflect critical thinking skills, including, among others, making predictions about a problem, collecting data and drawing conclusions, reflects the kind of classroom where students acquire critical thinking skills (Mathews & Lowe, 2011).

Classroom culture also has a role to play for students' acquisition of critical thinking skills. In the classroom setting where students are taking part in decision making and share authority with the teacher, students are encouraged and have self-esteem and they can engage in critical thinking skills (Mathews & Lowe, 2011). In such classrooms, teachers are providing constructive and motivating feedback rather than just evaluation comments(Mathews & Lowe, 2011). A setting with this kind of positive climate that can allow students to make mistakes and be given an opportunity for further learning can foster students' disposition toward developing greater critical thinking skills (Mathews & Lowe, 2011). Conversely, a classroom culture that focusses on transmission approaches to teaching and denies students opportunities to think and reflect on what they are learning cannot support the development of critical thinking and of meaningful learning for the individual (Mathews & Lowe, 2011). A classroom setting where the teacher is providing discouraging feedback and where students are required to memorise and reproduce scientific facts is less likely to nurture critical thinking skills (Buck, 2002). The authoritative nature of the classroom setting were the teacher-students relationship is supposed to be respectful, and where students are powerless, can limit learner-centred approaches to teaching (Schweisfurth, 2011) and so can limit learners' acquisition of critical thinking skills.

3.4 Scientific literacy

For successful science education, scientific thinking needs to be part of students' lives (Kuhn, 1993). An approach that can be useful in nurturing critical thinking skills in students' daily lives is to connect the science content and processes to students' daily life (Kuhn, 1993). According to Osborne and Dillon (2008), all students, including future citizens and future scientists, need to be educated as critical consumers of scientific knowledge so that they can deal with the dilemmas that are posed by the development of science and technology. According to DeBoer (2000), scientific literacy implies scientific understanding in a population. DeBoer (2000) noted various goals of science education, which include teaching science that is relevant to everyday life and educating learners to be informed citizens. Students do not need to be taught science for the aim of reproducing the content, theories and facts in examination; rather, they need to be taught and understand the usefulness of that knowledge (Kolstø, 2001). This implies that science education should aim at what is useful for the future citizen. DeBoer (2000) observed that having a community which is interested in science, and who can apply it in their daily lives and take part in discussion of various scientific issues, is important.

Norris and Phillips (2003) distinguished two notions of scientific literacy: the derived and the fundamental senses. The fundamental sense of scientific literacy implies ability in reading, comprehending, interpreting, analysing and critiquing scientific texts, which might be printed words, graphs, charts, tables, figures and others (Norris & Phillips, 2003). Scientific literacy in its fundamental sense implies the ability of an individual to understand and interpret various science texts and to differentiate their categories, like evidence, prediction, and speculation or claim. To be learned, educated or knowledgeable in science is the derived sense of scientific literacy (Norris & Phillips, 2003). A focus on the derived sense of scientific literacy, such as knowledge in science facts, creates an incomplete view of scientific knowledge as only facts, laws and theories in isolation (Norris & Phillips, 2003). According to Norris and Phillips (2003), to be familiar with laws, facts and theories on different scientific concepts in isolation, without the ability to interpret them, analyse them and criticise them, does not address all aspects of scientific literacy. Kolstø (2001) observed that students are like to encounter controversial issues in the society—for instance, those associated with health or the environment—which require them to act. Students need to be in a position to evaluate the relevance and trustworthiness of various scientific claims to be able to examine controversial issues (Kolstø, 2001).

3.5 Intrinsic motivation in science learning

The development of a theoretical framework that guides the exploration of students' intrinsic motivations in science learning was inspired by ideas from different scholars focussing on students' motivations (Eccles & Wigfield, 2002; Matsumoto & Sanders, 1988), meaningful science learning and link-making in science learning (Scott et al., 2011). Intrinsic motivation is an important aspect in science learning, as it makes the learner interested in the learning process, in contrast to extrinsic motivation which makes learners more interested in the ends of the learning task than the means (Matsumoto & Sanders, 1988). Situational interest that can result from learning context of a subject can be a source for students' permanent interests (Krapp, 2002). Both teachers' use of fascinating teaching approaches and the interesting content of a subject matter can result in this kind of initial, situational interest (Anderman & Maehr, 1994; Krapp, 2002) which can mature to permanent intrinsic interest (Krapp, 2002). Meaningful learning is another source of intrinsic motivation for students (Eccles & Wigfield, 2002). Meaningful learning can be attained by linking science from the classroom to students' daily lives (Scott et al., 2011). Thus, my theoretical model, used in exploring students' intrinsic motivations in science learning, indicates a link between intrinsic interests in science, connections made in class between science lessons to students' daily lives and meaningful learning. Further, there are two main factors involved in students' intrinsic motivations: situational factors and individual factors. Situational factors are related to teaching approaches in the classroom and the content of the subject, and individual factors are related to students' abilities, experiences and cultures (Anderman & Maehr, 1994).

4.0 Methodology

This chapter outlines the philosophical approach applied in my thesis; the methods used in data collection, analysis and interpretation; the trustworthiness of the research findings; and the ethical considerations and the limitations of the study. I also provide information regarding the choice of schools and participants in my study. In exploring the realisation of learner-centred teaching, I used several data materials which were analysed differently. This was useful in establishing the credibility of my study findings. The methods used for data collection involved interviews, group interviews, observation notes, video observations, and teachers' and students' comments on video clips. A detailed explanation of how each method was used in data collection and how the collected data were analysed and interpreted are also included in this chapter.

4.1 Research approach

This study aimed at investigating the realisation of learner-centred teaching in selected community secondary schools in Tanzania. The decision regarding the appropriate philosophical approach to be utilised in this study was guided by the problem under investigation. In distinguishing qualitative from quantitative research, Denzin and Lincoln (2011) noted that, while qualitative research focusses on socially constructed knowledge, quantitative studies focus on causal relationships among the variables under investigation. On the one hand, positivist quantitative researchers believe in objective realities (Creswell, 2003). To obtain the reality or the truth, in positivist perspectives, Lincoln, Lynham, and Guba (2011) noted the methods utilised should not allow the distortion of meaning by human.

On other hand, Denzin and Lincoln (2011) noted that, in qualitative research, observation is subjective. Interpretivists believe in multiple realities, and both the researcher and the respondent collaborate in creating meaning (Denzin & Lincoln, 2011; Mills, Bonner, & Francis, 2006). In this paradigm, the researchers' construct an understanding of a phenomenon by utilising information from participants together with their experiences and knowledge and the background of the study area (Treagust, Won, & Duit, 2014). My study goal was to focus on interpretations of respondents' voices and the context of my study to understand the practice of learner-centred teaching, which suits an interpretivist philosophical approach. Using an interpretivist perspective in this work, my experiences and background play a part in the interpretation of the phenomenon being studied. For instance, in my focus group study, students' voices were utilised and interpreted by the use of my experiences, background and knowledge to create an understanding with regards to what motivates students when they learn science in schools with contextual challenges. Also, teachers' interviews, observational notes and video materials were studied by collaborating with my respondents' voices, exploring the condition under investigation together with my knowledge and experiences to understand the practice and opportunities for inquiry-based science teaching in these schools. Participants contributed in creating this understanding of learner-centred teaching by providing information, and, in some instances, they were involved in the respondents' validation process. For example, when I was investigating the role of language of instruction for students' engagement in critical thinking skills, teachers and students commented on a video clip where language issues emerged and provided their understandings of the situation.

In qualitative paradigms, the researchers can start with data collection; the data collected are analysed to obtain themes and categories, then the synthesis that develops from those themes and categories can be linked to the extant literature and to the researchers' experiences to obtain theoretical generalisations (Creswell, 2003). Following the interpretivist approach in my study, I analysed the data collected to form categories and themes which were linked to the literature and to key theoretical notions. For example, in Article II, when I was exploring critical thinking skills in the video material, the categories in the video material were linked to elements of critical thinking skills suggested by the literature. Also, in the group interview study (article III), the interviews were analysed to form categories and themes based on students' voices, which were then explained through and linked to the theoretical framework.

4.2 Data collection techniques

In this study, teachers' interviews, observation notes, group interviews and video observations were applied as data collection methods, as presented in Table 4.1. These methods were utilised in responding to the specific research questions of my thesis in three articles, as indicated in the table. In answering the first research question, which was done in Article I, we utilised data from teachers' interviews and observation notes. We answered the second research question mainly by the use of video data; observation notes together with teachers' and students' comments on the video clips were used to enrich the credibility of the study findings. We used students' group interviews to answer the third research question.

Table 4.1. Data Collection

Research questions	Article	Interviews	Group interviews	Video	Obs. notes	Teachers' and students' comments
1. What role do contextual factors play in the practice of inquiry-based science teaching, specifically in the Tanzanian context?	**I**	√			√	
2. What are the potentials for inquiry-based teaching in community secondary schools in Tanzania?	**II**			√	√	√
3. What motivates students when they are learning science in schools with contextual challenges?	**III**		√			

4.2.1 Interviews

The teacher interviews provided data for investigating the practice of inquiry-based teaching in schools with contextual challenges. According to Kvale (1994), relevant interview questions should be evaluated thematically by considering how they relate to the research themes and theoretical framework guiding an investigation. The preparation of the interview guide that I used was guided by the theoretical framework on inquiry-based science teaching and the research question to be answered. I used a semi-structured interview strategy to ensure that teachers could elaborate on their experiences and their practices, but that, at the same time, they provided answers to the research question (see interview guide in appendix 1).

Before the administration of the interview, the questions were discussed and crosschecked by my supervisors and colleagues to ensure their relevance. Then, the questions were translated to Swahili, which is the familiar language for all the teachers that I interviewed, to facilitate smooth conversation and natural responses to the questions. The translated questions were also reviewed by a language expert to make sure that the meaning of the questions was sustained. To facilitate positive interaction with the participants, the questions were posed in such a way that they motivated teachers to talk about their personal experiences and their views (Kvale, 1994). For instance, this was done in the question which probes the practice of inquiry-based teaching, which stated 'Could you tell me of an interesting investigation you have been conducting with your students?' Then, I asked a follow-up question to probe for more clarification of the concepts and ideas and to explore unanticipated responses (Rubin &

Rubin, 2005). All interviews were audio-recoded and transcribed right after the interview. I then translated the transcripts to English prior to data analysis.

4.2.2 Group interviews with students

Group interviews were carried out in data collection for Article III. This was a case study taking place in six community secondary schools. In total, I conducted six group interviews with 46 students, in a group ranging from 7 to 8, one group at each school. The group interview is considered a better strategy than the one-to-one interview as it promotes self-disclosure for the participant (Krueger & Casey, 2000). This means that participants likely felt freer to contribute when they were in group than they would have in one-to-one conversations, which could create fear and tension for the students. To ensure a friendly relationship was established with students, I conducted the group interviews only after several visits to the schools. The interview questions were prepared following the procedure suggested by Krueger and Casey (2000), which requires that the questions be easy to say, clear, short and open-ended. Further, the questions were structured in such a way that the interview started with an opening question aimed to make students comfortable talking. The actual questions, focusing on the research question, were introduced in the middle of the conversation, while the closing questions were critical thinking questions that required students to think and provide suggestions. For instance, as a closing question, I asked students to think what they would have done as science teachers to make science interesting (see group interview guide appendix 2). In answering such a question, students had to reflect on their previous responses. The interviews were audio recorded, and a research assistant also copied, by hand, students' responses to the group interviews.

4.2.3 Video observations

In four schools, five teachers were filmed in their practical sessions and lecture sessions, while one additional teacher was filmed only in lecture session. In total, I filmed approximately 16 hours of class sessions. The purpose of the video study was to investigate the potential of inquiry-based teaching in these schools. The video material was utilised in Article II. By doing a video study, a researcher is able to collect data that might not be noted during note-taking in a usual classroom observation (Derry et al., 2010; Jewitt, 2012; Klette, 2009). Likewise, the method allowed the data material to be re-observed by multiple researchers, several times. Therefore, the method was considered more appropriate than note-taking. The filming process took place after several visits to the schools to establish rapport with teachers and students, so as to minimize the distraction of the sessions. Only one, fixed, small camera, placed on a stand at the back of the classroom, was used, to make the research less obtrusive (Jewitt, 2012). Each teacher had a small microphone placed in his or her pocket to capture teacher-student talk, as well as to capture students' conversations when the teacher was visiting groups of students in class.

4.2.4 Observation notes

In all the sessions where I did video observation, I also collected data through the use of observation notes. The observation notes aimed at collecting data for enriching the findings on the practice of practical work and inquiry-based teaching in schools with contextual challenges. It was unstructured observation. Guided by the research questions, I documented incidences in both practical and lecture sessions. For example, in the lecture sessions, I noted the activities conducted by both the teacher and students at the beginning of the session, at the middle of the sessions and during the closing of the sessions. I also noted important activities in the sessions—for instance, the questions asked in the sessions and during students' activities. Similarly, in practical sessions, I noted the materials provided for the experiment; how the experimental question, aim and procedures were communicated to students; how students started doing the experiments and the discussion incidences in the sessions. In practical sessions, I also noted how students communicated their findings. As video data captured by a single camera cannot provide sufficient information on its own, I considered taking notes to be important. I also took photographs in the sessions. Observational notes and photographs aided data analysis procedures and also enriched data obtained from the video records, as suggested by Derry et al. (2010). Likewise, the observation notes and photographs were used to enrich the findings for Article I.

4.3 Informants' backgrounds

Data collection was conducted in Iringa municipality (Iringa town), in Tanzania, during 2 time periods: from May to August in 2015 and from May to August in 2016. The study did not focus on all schools in Iringa municipality, but on community secondary schools. These are the common types of secondary schools established in all wards in Tanzania. Out of eleven community secondary schools in Iringa municipality, six schools were selected, purposefully. The aim was to obtain 3 schools without laboratories and 3 schools with laboratories to ensure the diversity of the schools. The schools without laboratories had either a science room where experiments could be carried out or a laboratory under construction, so students were doing experiments in the classrooms, with few resources.

46 students were selected for the group interview study in Article III. The pilot survey[3] served as a selection strategy. Students' responses to an initial, more broadly distributed questionnaire was one of the criteria for their inclusion in a group interview study. A mixture of those students who responded more positively, more moderately and more negatively were selected for the group interviews. Inclusion in a group interview was also partly determined by gender; both boys and girls were equally represented. Likewise, students in schools with laboratories and those from schools without laboratories were equally included in interviews. For teachers' interviews, the aim was to obtain one male and one female science teacher from each selected school, each with at least 3 years of teaching experience. These teachers were expected to provide rich data regarding their experiences with practical work and inquiry-based teaching under contextual challenges. However, this initial design was not perfectly enacted; particularly, I was faced with challenges meeting my goals for inclusion of female teachers. Female science teachers were fewer, compared to male science teachers, in the selected schools. One female teacher promised to participate but could not follow through on her promise because she was assigned other responsibilities. In some schools, the available science teachers had less than 3 years of teaching experience. Thus, 11 science teachers (4 female and 7 males) and some teachers with less than 3 years of teaching experiences were obtained for the interviews (see table 3.3). 7 teachers who participated in the interview agreed to be observed in practical work and lecture sessions, and the observation notes from these activities were utilised in the first and second articles. For Article II, 7 out of 11 teachers who participated in the interviews also participated in a video study. However, for one of these teachers, I encountered technical difficulties with the video clip, so this particular data could not be utilised.

[3] This was a questionnaire distributed in a class in each school studied. The questions were Likert type, focused on assessing students' attitudes towards science and their interest in school.

Table 4.2. Teachers Who Participated in the Study

Teacher	School	Teaching Subjects	Level of Education	Teaching Experience	Gender
Rachel	A	Chemistry Biology	Bachelor of Science in Education	5 years	Female
Daniel	D	Chemistry Mathematics	Diploma in Education[4]	3 years	Male
Timoth	B	Chemistry Biology	Diploma in Education	13 years	Male
Miriam	C	Chemistry Geography	Bachelor of Science in Education	3 years	Female
Mkude	E	Physics Chemistry	Diploma in Education	1 year, 2 months	Female
Ipuma	F	Physics Chemistry	Diploma in Education	1 year	Male
Theonest	B	Physics Mathematics	Bachelor of Science in Education	9 years	Male
Musa	C	Biology Agriculture	Bachelor of Science in Education	13 years	Male
Ipiana	F	Chemistry Biology	Bachelor of Science in Education	5 years	Female
Mkemwa	E	Physics Chemistry	Diploma in Education	4 years	Male
Robart	A	Physics	Diploma in Education	1 year, 6 months	Male

4.4 Data analysis

Various approaches for data analysis were conducted in this study. This was done to achieve triangulation, a way to ensure credibility of the study findings, as explained in detail in the section on trustworthiness of the findings. The approaches to data analysis that I used are elaborated in the coming sections.

4.4.1 Interview data analysis

I subjected the data from the teachers' interviews to thematic analysis procedures (Rubin & Rubin, 2005). The interview transcripts were first translated from Swahili to English. I repeatedly read the transcripts to identify themes relevant to the research questions. Using both inductive categories, which emerged from the data, and deductive categories, which I constructed from the theoretical framework and literature review, I coded all the data. Inductive categories refers to those categories which emerged entirely from data and which were not referenced in the extant literature I reviewed or in the theoretical framework I used for the study (see appendix 3).

[4] In Tanzania, teachers with a 'diploma in education' are those teachers who attended a 2 year course named 'diploma in education' after their advance level secondary education.

For instance, some of the responses from teachers regarding factors for conducting practical work were in line neither with the theoretical framework, nor with the reviewed literature, and were thus coded into inductive categories. One of the categories for these responses was 'motivation to use locally available materials'. Responses from teachers discussing such practices as the use of improvised chemicals, using materials in the environment or teaching osmosis by the use of local available materials were put in this category (motivation to use local available materials). Conversely, those categories from data that were in line with the theoretical framework and literature review were considered as deductive categories. For example, for the factors for the practice of practical work, resource availability was mentioned often by the reviewed studies. Thus, teachers' responses about problems such as lack of space for storing specimens, lack of equipment, small rooms and time limits were combined to form the category 'resource availability' (see appendix 3). The data analysis process was aided by NVIVO software.

A similar approach was utilised for the analysis of the group interview data in Article III. After every group interview, I completed a transcription. During transcription, I linked the hand written data with the audio data. After documenting all six group interviews, I read the transcript several times to become familiar with the concepts relevant to the research questions. The coding process was aided by the use of NVIVO 11 software for qualitative data analysis. The categories utilised during this coding process emerged from the students' voices (see categories and codes in the appendix 4).

4.4.2 Video data analysis

In Article II, we utilised video in exploring the potentials for inquiry-based science teaching. The video analysis followed an iterative approach, involving both inductive and deductive techniques (Erickson, 2006). According to Klette (2009), clarity regarding the theoretical framework and the criteria for the coding units is important to ensure the validity and transparency of the video analysis. Thus, in the video analysis, we applied various approaches to make the origination of codes and the theoretical framework valid and transparent. The analysis was guided by the main research question, which was about the potentials of inquiry-based teaching. Our sub-questions focussed on kind of questions addressed in the sessions, the critical thinking skills demonstrated and encouraged in the sessions and the role of the language of instruction in shaping questions and students' engagement in critical thinking skills. After the filming, the video was reviewed several times to study everything that was going on in the classrooms. Viewing the film several times guided further analysis. The development of the coding scheme and the coding of the video data were done iteratively, by moving back and forth in viewing the film and consulting the literature, always guided by the sub- research questions.

For instance, guided by my sub- research questions and by some previous studies (Chin, 2007; Chin & Brown, 2002; Oliveira, 2010), we coded various kind of questions, such as completely closed questions, moderately closed questions, moderately open-ended questions and completely open-ended question. For example, the closed types of questions were those questions in the video clips that required one, predetermined answer from the teacher. These were more teacher-centred kinds of question, where students could easily respond by retrieving the answers from their notes or text books. Examples of this type of question include: ‘What is an environment?’, ‘Who can mention some types of standard solutions?’, ‘What is a sense organ? or ‘Who remembers the meaning of titration?’ But questions which required students to apply their knowledge, through critical thinking, experiences or investigations, were categorized as moderately open-ended or completely open-ended questions. These kinds of questions were more learner-centred. Such questions include: ‘How do we apply knowledge of decantation in our daily lives?’, ‘Why do gases expand when heated?’ or ‘Why are plastic bags pollutants to the land?’

Also, previous studies, including Bissell & Lemons (2006), Lai (2011), Miri et al. (2007) and Willingham (2007) were reviewed to operationalize critical thinking skills. From this review and from viewing the video data, I identified various categories for critical thinking skills demonstrated in the video material, such as backing claims with evidence, asking for evidence for a claim, open-mindedness, applications of scientific knowledge, problem solving, and asking questions for clarification. For example, the category ‘asking questions for clarification as an aspect of critical thinking skills’ comprises questions from the teachers or students which were of a higher level considered to support reasoning and thinking. For instance, I categorized questions such as ‘What have you learned from the observation you have been doing?’ or ‘How can we use this knowledge of machines to move loads from the top of the building?’ as asking questions for clarification as an aspect of critical thinking skills.

The analysis process was facilitated by the use of the ATLAS STI package, which is qualitative analysis software that can enable the analysis of a large variety of data, including video (Lee & Esterhuizen, 2000) . For example, the software facilitated coding, writing a comment for a single code, forming families (categories) for codes in similar groups and writing memos for each research question. I used comments and memos in data interpretation. I explored the frequencies for codes of various kinds of questions and critical thinking skills and presented these frequencies in charts for each teacher observed. Transcription was only done for sample codes to illustrate the phenomenon of interest.

4.5 Trustworthiness of the findings

Trustworthiness is an important aspect of research. According to Guba (1981), the trustworthiness of research comprises the credibility, transferability, dependability and confirmability (objectivity) of the research findings. Credibility refers to how one can be confident regarding the certainty of the research findings (Guba, 1981). Prolonged engagement at the research site may help to overcome the distortions which may be imposed by the researcher's presence and biases (Guba, 1981). I conducted classroom observations for two extended periods of time for this study. I conducted the video observations in two phases, in 2015 and 2016, which facilitated the establishment of rapport with respondents and reduced the distortions which might result from my presence in the classes. Also, I collected data through student group interviews after several visits to schools to make sure that I established a friendly relationship with them, so that they could provide more valid data untinged by apprehension or nervousness.

According to Hammersley (2008), data triangulation may be used as a way to enhance the validity of the study and provide complementary information of the phenomenon under investigation. In Article I, I utilised interviews with teachers and observational notes in investigating the practice of inquiry-based teaching in schools with contextual challenges. In so doing, the information obtained by one method was crosschecked against others. Triangulation technique was also applied in Article II where, apart from video data, field notes and students' and teachers' comments were used to crosscheck the credibility of results.

The operationalization of the concepts in the study, such as inquiry-based teaching and critical thinking skills, were derived from previous studies to ensure their accuracy. In my study, I offer detailed descriptions of what was taking place during data collection and analysis, so as to enable the reader to evaluate the credibility of the results (Rubin & Rubin, 2005). Translations of the instruments and the informants' responses from one language to another have been reexamined to insure the validity of the study findings, as suggested by Temple &

Young (2004). The students and teachers who participated in the interviews in this study speak more fluently in Swahili than in English. Therefore, I determined to ask questions in their familiar language, as the most appropriate method to obtain rich data. The instruments in the data collection in this study were translated from English to Swahili, and the interview transcripts were translated back to English, which might raise a threat to the validity of the findings, resulting from the perceived potential for misinterpretations of questions and meaning. However, I personally completed the translation process, as a native speaker of the language of the informants (Swahili). Being a native speaker facilitated the selection of appropriate words relevant to the context and culture of the respondents. According to Temple and Young (2004), it is more beneficial for a non-objective researcher to be the translator in research, as he or she can pay attention to meaning and interpretation across cultures. Further, the translations were crosschecked by another language expert to insure that the meaning of the questions and interpretations were correct (Peña, 2007).

According to Guba (1981), transferability is another criteria for the trustworthiness of the research findings. Transferability refers to how the findings or conclusions drawn in a particular study can be applied in different contexts (Guba, 1981). Firestone (1993) argues that, to ensure the applicability of their findings, qualitative researchers need to provide a thick description of their studies. According to Guba (1981), having a thick description of the context facilitates readers' judgments regarding how the research fits other relevant contexts. In this study, I provided a relevant description of the research study, both in my thesis and in the articles, to enable the reader to compare the context of this study with other contexts. For instance, I provided a description of the way the sample for the study was obtained, of the question preparation for the interviews, of the lessons observed and of the data analysis procedures, including origination of codes and categories. Such information can be used by the reader in assessing the transferability of the results of my thesis.

According to Eisenhart (2009), theoretical or analytical generalisation is a kind of generalisation that is relevant for qualitative educational research. To attain analytical or theoretical generalisation, the researcher provides evidence that supports their theory. In Articles I and II, I linked the empirical findings of the study to the theoretical framework regarding definitions of critical thinking skills and inquiry-based teaching and discussed the findings and framework in relation to previous empirical studies. This kind of cross analysis offers an opportunity for analytical generalisation.

Dependability or reliability is regarded by Guba (1981) as the third criteria for trustworthiness and relates to the stability of the data. As described previously, I applied measures to ensure validity such as providing adequate descriptions of the research process, which, according to Shenton (2004), may aid other researchers in following and replicating the results. Triangulation techniques, which were also applied in this study, are useful in insuring the dependability of study findings when different data result in similar findings (Guba, 1981) . For instance, in Article I, the results obtained from the teachers' interviews were also confirmed by the observations. Video data which I utilised in Article II were open for further analysis with multiple researchers (Erickson, 2006). This characteristic enabled the data to be viewed and analysed by more than one researcher after the data collection process, which was advantageous for the study in facilitating the dependability of the study results. The viewing of the films by more than one researcher facilitated the crosschecking of the consistency of the coding process (Derry et al., 2010). I viewed the film several times with my supervisor (the second author of the second article) as a strategy to ensure reliability. I first completed the coding process to identify kinds of questions and critical thinking skills seen in the video material. Then, we revised the codes together to crosscheck the consistency. During the revisions, we revised some of the codes that did not appropriately or accurately fit the categories.

Confirmability is defined by Guba (1981) as a method of ensuring the trustworthiness of research findings by limiting or avoiding researcher biases and ensuring that the researcher's experiences and predictions are effectively tested. This approach ensures that all possible evidence for, and against, a claim is provided, not only those that support the researcher's predictions and experiences. In my thesis, I use triangulation as a technique to enhance the confirmability of my research findings. The data obtained was crosschecked against other data material (data triangulation).

4.6 Researchers' roles

My experiences as a former science student in schools with contextual challenges might have played a role in my interpretations of the research results and act as a source of bias; nevertheless, I use multiple approaches in data collection to limit such biases. I am, also, an experienced science teacher. I have been teaching in a teacher education college for one year and at the university college for about 3 years. I also witnessed similar contextual challenges when I visited my students in their field work. I have seen my students struggling with language barriers and with inadequate resources in science teaching. I have seen some student-teachers making a mistake of asking students facts-based closed questions in group thinking that they are practicing inquiry-based teaching or learner centred teaching. My experiences provided inspiration and strengthened my passion for my studies and for my PhD project. I have been teaching science methods courses and curriculum courses for upcoming teachers for some time. Such experiences have been important for the interpretations of data and documents I use in my present study. Having these experiences, as a former science student and a teacher, facilitated my work positioning myself as a researcher in this project. I played both outsider and insider positions. An insider, in a research context, is a researcher who possesses similar characteristics with the respondents, such as class or culture. Outsiders, in contrast, do not share such traits with their respondents (Mercer, 2007). When interviewing and observing teachers, my position was similar to that of a colleague (a fellow teacher) who wanted to learn more from the experienced teachers who have been in the classroom longer. This researcher-respondent relationship made informants comfortable, which allowed for the collection of valid data. Establishing trust with the respondent can facilitate the collection of valid data (Mullings, 1999). Similarly, when I interviewed students my position was that of a former science student who wanted to learn from their experiences, and not as much like a teacher or an authoritative figure. Such a relationship made more encouraging interactions possible. For instance, in our conversation, one student asked how she would benefit from the research I was doing and demanded proper clarification. In response, I explained to them that I was writing a research report which might be useful for policy makers when working on how to improve science teaching. Such an incident indicated that students felt secure, and they understood their rights in the process.

4.7 Ethical considerations

The respondents in my project are students, aged from 15 to 19 years, and adult teachers. For the study to be conducted, I first applied for research permits from several different authorities, starting with the Norwegian Social Science Data Service (NSD). Then, my application letter was sent to the University of Dar es Salaam Directorate of Research in Tanzania and the agency of Ministry of Education and Vocation Training, asking for issuance of a research permit. After that, a letter of request was sent to the Iringa region administrative secretary, and, thereafter, to the Iringa Municipality Director, as Iringa was the region where the research would take place. After I got the consent from the abovementioned bodies, a letter from the municipal director was sent to the heads of the schools where the research was taking place. During my visits to the schools, I presented the informed consent forms to the heads of the schools, the teachers and the students participating in the study. After being introduced to the teachers, I presented the consent forms to them and provided them with detailed descriptions of my research. I also insured the confidentiality of the information they provided. Only those teachers who agreed to take part in the research participated. A few of the teachers participated in interviews but felt they were not ready for a video study; I respected their selective participation. I also respected the wishes of those who agreed to participate and then changed their minds during the process. Only those teachers who agreed and signed the consent forms were included in my study.

The ethical issues in research applied to adult informants should also be considered when one is doing research with children (Morrow & Richards, 1996). The students involved in my study were adolescents, aged 15 to 19 years old, and, according to NSSD regulations, were of an age to decide whether or not they wished to participate in research studies. Students participated in group interviews and video observation. I established a rapport with them, by visiting them several times, explaining to them who I was and the purpose of my research, and clearly articulating what would their responsibilities would be if they agreed to participate in the study. As suggested by Morrow & Richards (1996), researchers have to explain the purpose and nature of their research clearly and explicitly to children and to adult gate keepers when seeking consent from children for research. The consent forms were presented to students both orally and in paper-based forms, depending on student circumstances. Students who participated in the study all willingly agreed to participate. During video observation, students were told that they were free to choose whether to participate or not. For those who might not be ready to be recorded by the camera, the camera was focused in the other direction so that they could not be recorded. For those who were recorded, their identities are anonymous in the research report. All students agreed to participate in the video study and to be recorded.

4.8 Limitations of the study

There are several limitations to this study. First, I had to translate the transcripts from Swahili to English during data analysis. Translation of the instruments and transcripts from one language to another may cause a threat to validity of the study findings (Temple and Young 2004). To ensure appropriate translation across cultures and to avoid distortion of the findings, the translations in this study were performed by the first author, who is a native speaker of the language of the respondents (Temple and Young 2004).

Second, my intention was to select teachers with more than three years of teaching experience, including both men and women. However, in some schools it was difficult to have experienced science teachers, as well as female teachers. Nevertheless, my informants provided useful information regarding the learner-centred teaching

Third, although teachers agreed to participate in the observation, not all of them participated after all. As a result, I was not able to observe all teachers that were interviewed. However, the credibility of the study findings were insured, since I have employed the data triangulation strategy.

Finally, the video observation was conducted mainly in two sessions (one session lasting up to 80 minutes) per participating teacher. This may not be considered as a sufficient criterion for fully evaluating teachers' practices, since teachers might have varied teaching activities. Nevertheless, the findings of the observational study were useful for illuminating the practices that can be implemented and tested for practical work and inquiry-based teaching in schools with contextual challenges.

5.0 Summaries of the Articles

This chapter presents a summary of each of the three articles of my thesis. I briefly present overviews of the background and methods as well as the summarised results from each article. All three articles contribute to understanding of learner-centred teaching in community secondary schools in Tanzania. Article I explores the role played by contextual challenges for practising inquiry-based science teaching in the schools studied, which forms the basis for the other two articles. In further exploring learner-centred teaching, Article II, which is the video study, explores the potential for inquiry-based teaching in the schools, and Article III, a group interview study, examines students' intrinsic motivations in science and indicates the links between learner-centred teaching and students' intrinsic motivations.

5.1 Article I

Mkimbili, S., Tiplic, D., & Ødegaard. M. (2017): The Role Played by Contextual Challenges in Practising Inquiry-based Science Teaching in Tanzania Secondary Schools. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(2), 1-11.

5.1.1 Background and methods

In this study, we explored the practice of inquiry-based teaching in schools with contextual challenges in Tanzania. The constructivist approach to teaching, in which learners are taking an active role in knowledge creation, has been adopted by various sub-Saharan countries, including Tanzania (Vavrus et al., 2013). The current Tanzanian curriculum is learner-centred and follows a constructivist notion of learning (MoEVT, 2005). One of the key general competencies students are supposed to acquire, according to the Tanzania curriculum, is critical and creative thinking. The curriculum emphasises that critical thinking skills ought to facilitate students' understanding of how new knowledge is attained, assessed, advanced and reformed in the field (MoEVT, 2005); inquiry-based teaching in science subjects can support the development of such understandings (Hofstein & Kind, 2012). In Tanzania's ordinary level science syllabi, the notion of inquiry-based science teaching, in which students take part in activities such as designing investigations (MoEVT, 2007), collecting data and analysing, interpreting and communicating findings (MoEVT, 2010a) are highlighted. Meaningful practical work involves learners in inquiry-based teaching (Abrahams & Millar, 2008). In the Tanzanian context, practical work is given much emphasis, and students take final practical examinations in all science subjects at the end of their ordinary level secondary educations

(MoEVT, 2005). Despite the fact that the curriculum emphasises inquiry-based teaching, however, studies have revealed various factors that limit the practice of practical work (Osaki, 2004; Semali & Mehta, 2012) which can, then, also limit the practice of inquiry-based teaching. To address the main aim of this article we had two specific research questions, as follows:

1. What levels of inquiry-based science teaching is being practised?
2. What contextual factors influence the practice of inquiry-based science teaching?

To answer the research questions, eleven science teachers from six schools participated in interviews, and I observed seven of the eleven teachers in their practical activities, while taking observational notes. The NVIVO software facilitated the analysis of interview data.

The framework for levels of inquiry-based teaching from Jiang and McComas (2015) guided the analysis of data. The framework has four levels of inquiry-based science teaching, examining students' involvement in asking investigation questions, designing the investigation, conducting the investigation activities and drawing conclusions from the findings.

5.1.2Results

The results revealed that, in the schools we studied, practical work was done infrequently and mainly as a preparation for the practical examinations. Factors that limited the practice of practical work, as mentioned by teachers, involved inadequate resources, congested classes and time limitations. Some teachers commented that resources for practical work were mostly available during the preparation for national examinations; thus, teachers had the opportunity to involve students in practical work during examination preparations. Much emphasis in the science syllabus is on kinds of practical work that can be assessed by practical examinations; such work is often recipe-based practical work, where students conduct practical work by following clear guidelines. Directed by practical manual syllabi and previous national examination questions, teachers explained that they prepare practical work for their students that can mainly accommodate low levels of inquiry-based science teaching.

The stress placed on practical examinations and the inadequacy of resources impacted the levels of inquiry-based science teaching in the schools studied. Results from both interviews and classroom observation indicate that even the low levels of inquiry (conducting activities and drawing conclusions) were infrequently practised, while the higher levels of inquiry (asking questions and designing investigations) are either not done or rarely done. This result can be explained by the fact that the lower levels of inquiry are, in fact, the ones that can be evaluated during national examinations. Although the main objective in the syllabus indicates that at the end of the ordinary level secondary education, students ought to be able to design investigations, real implementation in the classroom was deemed not feasible by most of the teachers interviewed. These higher levels of inquiry were hardly ever practised in the studied schools. This was not a surprise, to me, as a researcher, as I already knew these skills were considered unimportant, because they cannot be assessed by practical examinations. Other factors that limited the practice of inquiry-based science teaching in the visited schools involved the use of a foreign language (English) as a language of instruction, inappropriate teacher training, and teachers' perceptions and beliefs regarding inquiry-based teaching and students' abilities. Teachers explained that involving students in discussion and communication about their findings during experiments is very difficult, as most students are not fluent in the language of instruction and consider discussion in a foreign language, about science difficult. Most teachers expressed concerns regarding the feasibility of practicing inquiry-based teaching considering the abilities of their students. According to teachers' explanations, practical work ought to be teacher-centred. Nonetheless, in this study, we noted some possibilities of inquiry-based science teaching which were interesting. One of the possibilities was involving students in questions that linked science and students' local contexts. Some teachers described how they use questioning techniques to link practical work with daily life, which we interpreted as a possibility for further inquiry-based teaching. Another possibility of inquiry-based teaching noted in our result is the use of improvised resources from local contexts to support students' investigations. During interviews, some teachers explained that they improvised various resources to facilitate students' practical work, which can then facilitate inquiry-based teaching; I also noted this strategy in one session of classroom observation.

5.2 Article II

Mkimbili. S., & Ødegaard. M. Potentials for Inquiry-based Science Teaching in Community Secondary Schools in Tanzania. Submitted to *Cultural Studies in Science Education*.ms.39

5.2.1 Background and methods

In this article, we explore the opportunities for inquiry-based science teaching in community secondary schools in Tanzania. Swahili is a familiar language (first or second language) for the majority of Tanzanians. Following the guidelines of the 1995 Education and Training Policy of Tanzania, Swahili should be used as a medium of instruction in pre-primary and primary education, and English (a foreign language) should be used as the medium of instruction in secondary and tertiary education. The 2005 Tanzanian ordinary level secondary education curriculum focusses on learner-centred approaches to teaching which follow constructivist notions of learning (MoEVT, 2005). According to the 2005 curriculum, the teacher is expected to be a facilitator and motivator, and students are expected to play active roles in learning. The competence-based curriculum suggests that the activities planned by teachers in science lessons should give students opportunities to ask questions, to be involved in critical thinking and to develop new ideas (MoEVT, 2005, p. 29). Previous studies have noted that students' active involvement in learning is compromised in Tanzania as a result of insufficient competence in the foreign language of instruction (Brock-Utne, 2007; Vavrus et al., 2013; Wandela, 2014; Webb & Mkongo, 2013). Both teachers and students face language problems during teaching and learning (Wandela, 2014), which act as a hindrance for learner-centred teaching. We aimed at exploring the opportunities of inquiry-based science teaching in such contexts through the use of a video study to enrich previous findings which had mainly relied on note taking (Brock-Utne, 2007; Wandela, 2014). In this study, we had 3 specific research questions:

1. What types of questions do we observe from teachers and students during the sessions?
2. What kind of critical thinking skills do we see?
3. What is the role of the language of instruction for student-teacher talk in the sessions?

To answer our research questions, we conducted video studies in four schools. We followed six teachers in their practical work and lecturer sessions, for 16 hours in total. After filming we interviewed 6 teachers and 18 students who participated in our study to enrich our findings. Also, we utilised notes taken during filming in the analysis process. We iteratively analysed data by applying both inductive and deductive approaches with the help of the ATLAS STI program. Inspired by other studies (Chin, 2007; Chin & Brown, 2002; Oliveira, 2010), we coded questions in our video material into completely closed questions, moderately closed questions, moderate open-ended questions and completely open-ended questions. For critical thinking skills, we used a framework developed by other studies (Bissell & Lemons, 2006; Lai, 2011; Miri et al., 2007; Willingham, 2007) to code the following elements of critical thinking skills in our video material: backing claims with evidence, asking for evidence for a claim, open-mindedness, application of scientific knowledge, problem solving, asking questions for clarification and drawing conclusions from the available facts. We used the interview data and observation notes together as a triangulation strategy.

5.2.2 Results

Our results revealed that the types of questions that were preferred by teachers, both in practical work and lecture sessions, were fact-based, closed types of questions that require students to recall science content with no further probing of students' thinking. In some cases, teachers asked students open-ended questions or followed up with further questioning to probe students' thinking. Students participated better in answering open-ended questions in Swahili than when they did in English. During interviews, both teachers and students agreed that insufficient competence in the language of instruction is among the challenges for any interactive approach to science lessons. Students did not ask any questions when required to talk in English, but they asked several questions when allowed to talk in Swahili; this implies that the use of a familiar language may facilitate students' involvement in asking and answering questions of higher levels, which may present opportunities for their acquisition of critical thinking skills.

In our analysis of the video data and the interviews, we have observed other factors that limit students' questioning and responding to questions. These factors include classroom cultures and teachers' understanding of the nature of science. Students commented that they were not free to respond to questions; they did not feel as if they were allowed to make mistakes. This finding disclosed that, in the classroom, students are supposed to provide only true answers, and they cannot take chances in making mistakes. Such restricting contexts cannot foster students' creativity. This kind of classroom culture could be explained by the cultural context where teachers are more powerful than students; given this context, it is not easy for teachers to share power with students which is a limiting factor for learner-centred teaching (Schweisfurth, 2011). Teachers' responses in the interview indicated that some of them expected only one correct answer from the students, which answer had to be from what was taught. Some teachers commented that students cannot ask or answer a question when they are learning a new concept. This is an indication that teachers have narrow understandings of the nature of scientific knowledge. They consider that scientific knowledge from the text book is the only true knowledge which needs to be conveyed to students.

In our data material, we observed several critical thinking skills as identified by our framework: drawing conclusions from the available facts, application of scientific knowledge, problem solving, open-mindedness, backing claims with evidence and asking questions for clarification. Critical thinking skills were mostly observed in the sessions where students were given opportunities to design their investigations by using locally available resources, when teachers used students' daily lives in teaching and when the use of a familiar language was applied in answering open-ended questions. We interpreted those instances that supported students' involvement in critical thinking in our data material as having potential for inquiry-based teaching. The comments from teachers and students in our material have also indicated that the use of a foreign language in science teaching may limit students' involvement in developing critical thinking skills. Students' involvement in investigations using locally available resources and asking and answering open-ended questions when using a familiar language were interpreted as showing potential for inquiry-based teaching in our data material. In our video material, we also observed that the classroom culture at hand offers certain explanations for the students' involvement, or lack thereof, in demonstrating critical thinking skills. We observed that, in a context where the teacher took a less authoritative role, allowing students to come up with various answers and problems, students were more involved in the elements of critical thinking, such as open-mindedness, problem solving and applications of science. But in more authoritative classes, students' engagements in critical thinking skills were rare.

5.3 Article III

Mkimbili. S., & Ødegaard. Student Motivation in Science Subjects in Tanzania, Including Students' Voices; Accepted with minor revision to *Research in science education*.

5.3.1 Background and method

In this study, we aimed at exploring students' motivations in science subjects in schools with contextual challenges. Students' interests in science are important for ensuring their attainment of scientific literacy. When science is interesting to students in school, they may continue learning even outside formal contexts (DeBoer, 2000), thus acquiring scientific literacy. The Tanzanian Education and Training Policy emphasises the need for scientific literacy in Tanzania because it is important to make people productive for national development and to enable people to acclimatize to their environment (MoEVT, 2014). Citizens' acquisition of scientific literacy is important for the national welfare. Previous studies from the Tanzanian context have indicated that students are demotivated from studying science as a result of challenges in science education, such as limited resources (Mabula, 2012; Ndalichako & Komba, 2014; Nyamba & Mwajombe, 2012) and unfamiliarity with the language of instruction (Ndalichako & Komba, 2014). Students' demotivation with regard to science learning may prevent them from acquiring scientific literacy. Thus, in this article, we investigated students' motivations when they were studying science in schools with contextual challenges, focussing mainly on students' voices on the issue. The research question was 'What motivates students when they are learning science in schools with contextual challenges?' To answer the research question, we conducted six group interviews in six schools with 46 respondents. A group interview lasted 1 to 2 hours, and we audiotaped and transcribed the interviews. NVIVO II software aided coding procedures and retrieving codes within similar categories. The categories for data coding emerged from students' voices.

5.3.2Results

Students in this study identified various challenges in their science learning. Students elaborated that they lack important resources in science learning, such as textbooks, lab equipment and sufficient numbers of science teachers, particularly in physics. Students explained that those challenges limit their science learning and their interest in science subjects. Other challenges posed involve the use of a foreign language in science instruction, transmission approaches to teaching and an overly high volume of content to be covered.

Students disclosed various factors that make scientific aspects interesting from their perspectives. Relevance of scientific topics was one of the factors for students' interests. Students mentioned that they considered topics in science subjects that were applicable in contemporary society, such as diseases and environmental conservation, and those that were linked to their activities at home, such as farming, interesting. The topics that were useful in society, such as those applicable in medical careers, like first aid, and those that were dealing with society issues, like culture aspect linked to science, were perceived as interesting. Genetics was considered useful in dealing with solving cultural[5] problems, such as issues of albinism and gender. For instance, some students explained that, after studying genetics, they can solve conflicts in families when couples are only getting female or male children.

The use of hands-on activities was also an approach that was mentioned as interesting. Many students disclosed that they were interested in tangible and observable aspects of practical work. Students explained that hands-on activity is useful for students who have not yet mastered the language of instruction. Students voiced that practical work can facilitate meaningful learning in a context where students are using a language in which they are not sufficiently fluent. Another approach that students disclosed that makes scientific aspects interesting is the use of discussion and questioning techniques. Students revealed that the use of discussion enabled them to integrate their thinking and understanding and facilitated meaningful learning. Students also mentioned that teachers' ways of teaching and relationships with students play a part in the students' interests in science. Students expressed that when the teacher includes students' voices, experiences and thinking, he or she makes scientific aspects interesting. Students elaborated that providing real life examples can facilitate easy understanding when students are using a foreign language for science content learning. Students expressed that the use of examples from daily life can raise students' confidence in their science learning and can help learners integrating their experiences in science learning, both of which are important for nurturing students' interests in science. Formative assessment and interactive techniques make learners take active roles in the lessons and raise their interest.

[5] In some communities in Tanzania and Africa peple have belefs that albino are not like normal person, and they can be a source of wealth once killed. Also in some communities male kids are more preferred than female kids, thus a worman can be blamed if she only have female kids.

In this study, we also reflected on students' voices with regards to what needed to be done by teachers and curriculum developers to make science interesting in schools with contextual challenges. Students disclosed that, for science education to be interesting for students in their contexts, science teaching and learning in the classroom need to involve students' voices. Students expressed that when they are involved in hands-on activities by the use of local materials, when they are involved in science discussions and when the teacher uses examples from learners' contexts to link science from the classroom to their lives, they are more interested in science learning. Students also suggested that curricula that are more inclusive of students' experiences and culture are more interesting. For instance, some students suggested that irrelevant aspects to students in the curriculum need to be revised to include more relevant scientific aspects. Students disclosed that curriculum materials, like text books, need to offer context-relevant materials to make understanding easier, particularly when students are using a language in which they are not fully competent. Students disclosed that, to make science interesting to most students, curriculum developers need to ensure that resources such as textbooks, lab equipment and science teachers are available. Students expressed that students' failures in science and lack of interest in science is largely explained by the limited resources in the schools. With respect to the language of instruction, students suggested that the language that is used in science content learning need to be thoroughly mastered by the learners in primary and secondary education, whether that language is English or Swahili. Students noted that they fail to ask and respond to questions appropriately as a result of insufficient competence in the language of instruction.

6.0 Contributions of the Study

The major aim of this study was to investigate the practice of learner-centred teaching in community secondary schools in Tanzania. Learner-centred teaching links to inquiry-based science teaching, students' disposition of critical thinking skills and their intrinsic motivations. I answered three main research questions in this thesis:

1. What role do contextual factors play in the practice of inquiry-based science teaching, specifically in the Tanzanian context?

2. What are the potentials for inquiry-based teaching in community secondary schools in Tanzania?

3. What motivates students when they are learning science in schools with contextual challenges?

In this chapter, I focus mostly on articulating the major contributions of my study. The main contribution of my thesis, which I will discuss in this chapter, is the exploration of the practice of and promising opportunities for learner-centred teaching in community secondary schools in Tanzania and its role for students' intrinsic motivations in science. This main contribution is organised 3 sub-sections which are:

1. The practice of inquiry-based science teaching in schools with contextual challenges.

2. Opportunities of the practice of inquiry-based science teaching.

3. The link between learner-centred teaching and students' intrinsic motivations in science.

6.1 Practice of Inquiry-based Science Teaching in schools with contextual challenges

The definition of inquiry-based science teaching is guided by the framework developed by Jiang and McComas (2015). Following this framework, we investigated the extent of students' involvements in the elements of inquiry-based teaching, which include asking investigation questions, designing the investigations, drawing conclusions from the investigations and conducting activities. In Article I, we have noted that the practice of higher levels of inquiry, such as asking investigation questions and designing investigations, was seldom done by students in Tanzanian contexts. Not only were the higher levels of inquiry-based science teaching, as identified by Jiang and McComas (2015), not well-practised in the studied schools, our results in Article I, particularly the responses from teachers' interviews and classroom observations, revealed that students were involved in conducting experiments and drawing conclusions from the experiments infrequently and mainly as a preparation for national examinations. The findings indicate that the main focus in experiments is to make sure that students follow the procedures to replicate known results. Teachers disclosed that practical work was structured following the practical manuals, syllabi and previous examinations to teach students what would be needed in answering fact-based national examinations. The observations revealed that little time was allocated, in the few sessions observed, for students to discuss and interpret their experimental results. A study conducted by Abrahams and Millar (2008) observed that the aspects of inquiry were not the main focus for practical work in schools. Little emphasis was allocated to students' involvements in data collection, analysis and interpretation of data. Hattingh et al. (2007) noted, in their study, that the practical work conducted in the science lessons were mostly recipe-based kinds of activities; the higher levels, such as designing investigations, were seldom engaged. Based on this findings of this study, I argue that the practice of inquiry-based teaching is problematic in the schools studied; the major intention of practical work is to use recipe-based kinds of activities to facilitate students' capture of scientific facts.

The findings of my thesis disclosed surprisingly, perhaps, that the emphasis placed on practical examinations is one of the limiting factors for students' involvement in higher levels of inquiry. Teachers disclosed that they used syllabi, practical manuals and previous practical examinations to design the experiments for their students, which focussed mainly on recipe-based activities. Some teachers claimed that asking investigation questions and designing investigations are tasks that cannot be done by students and that students have to follow the procedure as directed by the teacher. Students were supposed to follow procedures to produce or confirm known scientific facts. The observations disclosed that most of the practical work focusses on making students follow and memorise the procedures. The general objectives from the learner-centred curriculum of Tanzania aimed at students' acquisition of inquiry-minds, and it suggested students be involved in posing problems and solving the problems presented by the teacher (MoEVT, 2005). However the examinations are still fact-based, contrary to the revised learner-centred pedagogy (Vavrus et al., 2013; Wandela, 2014).

Specific objectives in the science syllabi of Tanzania emphasise what is needed in answering fact-based examinations (Wandela, 2014). The practical skills that students have to acquire by the end of their education need to be well-identified and assessed so as to ensure learners' attainment of the target skills (Abrahams et al., 2013). For students' attainment of skills in higher levels of inquiry, as identified by our framework, both teachers and educational stakeholders need to be aware of such skills and how they can be practised and evaluated. If the skills students are expected to achieve in practical work are not carefully identified and assessed, then the practical work becomes just a way to achieve higher grades in examinations, not a method for learning investigative skills (Abrahams et al., 2013). Based on these findings, I argue that the practice of the higher levels of inquiry-based science teaching cannot be properly done by students in Tanzanian contexts because these skills are not the focus of the specific objectives in the syllabus and the national examinations. Although they are highlighted by the broad curriculum goal, they cannot be practised in the classroom if they are not assessed by the national examinations and they are not well communicated in the syllabi or to the teachers.

The language of instruction is another limiting factor, as disclosed by the findings of this study, for the practice of inquiry-based science teaching in schools studied in Tanzanian contexts. Teachers' interviews in Article I revealed that students fail to discuss and communicate their experimental findings using English. Article II, the video study, disclosed that teachers and students face difficulties when using an unfamiliar language in the kind of open discussion that can otherwise foster critical thinking skills, such as application of science, problem solving and asking questions for clarification. In Article III, a focus group of students pointed out that they sometimes failed to explain themselves because they were using unfamiliar language; thus, students remain silent and uncritical in their science lessons. Most elements of critical thinking skills in the video study, like open-mindedness, drawing conclusions from the facts and backing claims with evidence, appeared when the teachers integrated Swahili during teaching. The overall findings from this thesis have indicated that the use of English in science teaching is a major contextual challenge for students' involvements in critical thinking skills, such as problem solving, application of science and drawing conclusions. Previous studies have also disclosed the difficulty of practice of inquiry-based science teaching (Vavrus et al., 2013) and students' involvements in critical thinking skills (Brock-Utne, 2007; Webb & Mkongo, 2013) while using an unfamiliar language of instruction (English) in Tanzania contexts. This implies that learning science in an unfamiliar language makes student involvement and development of critical thinking skills difficult. Students will be asked questions mostly to evaluate their memorisation of scientific facts. Students can hardly be involved in critical thinking skills and be able to connect what they learn from the classroom to their daily life if they are also trying to overcome the problems of an unfamiliar language of instruction(Webb & Mkongo, 2013). For students to be involved in learner-centred approaches in Tanzanian contexts, which can nurture students' critical thinking skills such as open-mindedness, application of science and drawing conclusions, the use of familiar languages for instruction is essential.

Insufficient teacher training was noted in the findings of my thesis as yet another challenge for the practice of inquiry-based science teaching in the studied schools. In Article I, some teachers disclosed that they were not in a position to prepare more experimental teaching when they graduated from their bachelor degree programs. Also, teachers interviewed in Article I disclosed inadequate understandings of inquiry-based science teaching; they consider that, by asking the students fact-based questions, they are engaging students in learner-centred teaching. Some students in the group interviews in Article III also commented that some teachers used transmission approaches, making students only copy notes and calculations. The results in Article II further indicated that teachers have insufficient knowledge with regards to the nature of scientific knowledge. Some teachers disclosed that students' responses to questions depend solely on what they have been taught by the teacher. Such thinking made teachers mostly rely on facts-based questions and create classroom cultures that were not supportive for students' acquisition of critical thinking skills. These findings indicate insufficient teacher training. Wandela (2014) observed that, in Tanzanian contexts, inquiry-based science teaching is not well-emphasised in some teachers' colleges. Despite the emphasis on learner-centred teaching and on developing inquiring minds in students, as advocated in the curriculum (MoEVT, 2005), teacher education and preparation do not emphasise inquiry-based science teaching. Ogunniyi and Rollnick (2015) noted that most African science curriculums have put emphasis on interactive ways of learning but, there is no sufficient emphasis for preparing teachers who can implement inquiry-based teaching. From the findings of this study, I argue that inadequate involvement in inquiry-based science teaching in the schools studied can be explained by insufficient teacher training on the nature of scientific knowledge and on inquiry-based science teaching.

Classroom cultures, as well as the larger cultural context, have been disclosed by the findings of my thesis as another limiting factor for students' involvements in inquiry-based science teaching and their engagement in critical thinking skills. The findings of Article I revealed that teachers need to follow what is required by the syllabus and the examinations in their teaching. Teachers are working under the pressure of the national authorities and examinations, and they are not free to allow students' engagement in critical thinking skills; they see it as waste of time. This contextual factor in developing countries, where teachers are working under the pressure of authorities and the national examinations, can hardly facilitate the practice of learner-centred teaching (Schweisfurth, 2011). Similarly, the classroom culture portrayed by the results of all three articles indicates that, in the context of the schools studied, the classroom culture is not supportive for students' engagements in critical thinking skills. For instance, in Article I, most practical work observed required learners to follow the given procedures to reproduce only one known result, with limited student discussion and strict teacher supervision. In Article II, some teachers disclosed their beliefs that students need to provide single, true answers based on science content taught, and most questions asked were fact-based, closed questions that required one, predetermined answer. Students in the group interview study, Article III, voiced that their main tasks in some sessions were copying notes and calculations, and they were given little time for discussion. Such classroom cultures, where the teacher takes on an authoritative role and provides students with tasks that focus on evaluation of facts under strict teacher supervision do not nurture students' critical thinking skills, such as problem solving, open-mindedness and backing claims with evidence (Mathews & Lowe, 2011). Thus, students' inadequate engagement in inquiry-based science teaching and critical thinking skills in the studied Tanzanian schools can be explained by the cultural context and by classroom cultures that are not adequately supportive for students' creativity and critical thinking skills.

6.2 Opportunities for the practice of inquiry-based science teaching

One of the important contributions that has been disclosed in this study is the potential for inquiry-based science teaching in the schools studied. Findings in all three articles have proposed alternative approaches for practice of inquiry-based science teaching in these schools. In Article I, we have noted that the use of locally available material and investigative questions that link science with students' daily lives may be utilised as offering potential for inquiry-based science teaching. Similarly, in the video study of Article II, the main potentials for inquiry-based science teaching involved the use of locally available materials and integrating familiar language use for students' investigations. According to Ramnarain and de

Beer (2013), when students use resources from their schools and homes for investigations, they are involved in meaningful learning, even in challenging settings, such as schools with large classes, inadequate resources and large content coverage expectations. In the presence of a motivated and well-trained teacher, physical resource availability cannot prevent the practice of practical work, because the teacher will find a way to integrate relevant practical work in any context (Hattingh et al., 2007). The practice of inquiry-based science teaching need not rely on lab experiment. Well-trained and motivated teachers can involve learners in an inquiry-oriented activity, even outside lab work.

Another potential for inquiry-based science teaching emerging from this study is the use of open-ended questions. In the video study, Article II, we observed that, when the teachers used open-ended questions and integrated familiar language in class discussions, students were more involved in critical thinking skills, such as open-mindedness and backing claims with evidence. We interpreted these incidents as offering clear potential for inquiry-based teaching in the schools. In Article I, we have noted that questions that link science from the classroom with students' daily lives offer potential for inquiry-based science teaching. Open-ended questions can be used for nurturing critical thinking skills, such as problem solving and application of science, in learners, making them scientifically literate. The questioning technique can be utilised to facilitate inquiry-based science teaching in large classes (Chin, 2007). From a social constructivist perspective, in science learning, learners are bringing their background knowledge to class; this knowledge needs to be mediated into scientific ways of knowing (Driver et al., 1994). In asking and answering open-ended questions, learners bring their thinking and experiences of science and integrate them with scientific knowledge. From this finding, I argue that questioning techniques, if appropriately applied in Tanzanian contexts, can offer potential for inquiry-based science teaching and contribute to scientific literacy in Tanzania's population.

6.3 The link between learner-centred teaching and students' intrinsic motivations in science

The link between learner-centred teaching and students' intrinsic motivations in science is an important contribution of my thesis. This contribution has been disclosed mostly in Article III. The findings have disclosed that, for science to be interesting to the majority of students in the schools studied, it has to be inclusive of students' voices in the educational policy, curriculum, and classroom activities, as indicated in figure 1.

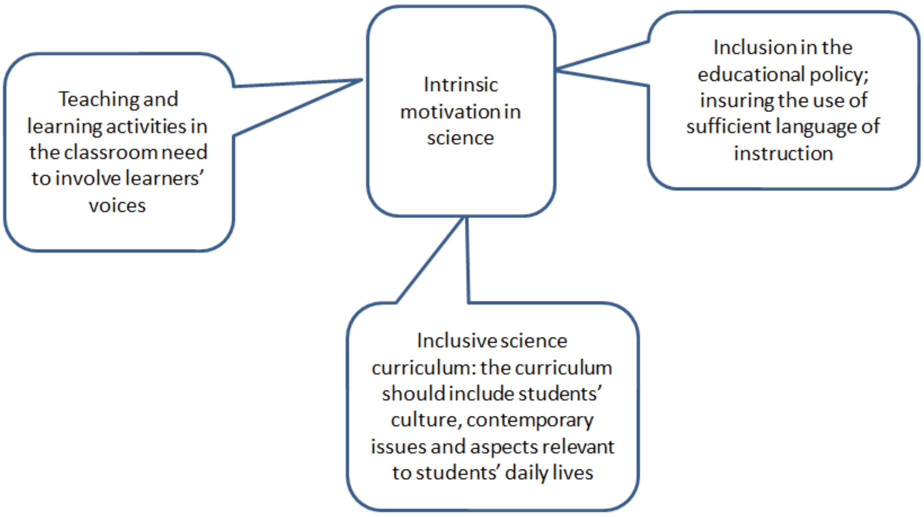

Figure 6.1: Link between motivation in science and inclusion of students' voices, as suggested by students' voices in this thesis

6.3.1 Inclusion of students' voices in educational policy

Students in Article III disclosed that they found active engagement in science difficult, particularly engagement in discussion, because they are not competent in the language of instruction. When asked what needed to be done to make science interesting from their perspectives, students disclosed that the language to be used in science teaching needs to be well-developed from primary to secondary schools, whether that language is English or Swahili. Students expressed that the educational and training policies need to ensure that the language that is used for content learning is thoroughly mastered before it is used as the medium of instruction. The policy need to be considerate of the authenticity of the language of instruction in facilitating students' active learning. The 1995 educational and training policy recommended the use of English as the medium of instruction both in secondary and tertiary education (MoEC, 1995). The newer, 2014 educational and training policy requires the use of both Swahili and English as languages of instruction at all levels of education (MoEVT, 2014); however, the use of Swahili in secondary schools is not operational as yet. Currently, all curriculum materials are only available in English, and students take the national examinations in English. In Article II, we observed that having national examinations in English in Tanzanian contexts makes teachers encourage students to use only English in the lessons, so as to be able to respond better to examinations questions. This encouragement, though, suppresses students' voices because student cannot talk well in English. The use of

English in teaching limits dialogue between teachers and students and impedes learner-centred pedagogy (Vavrus et al., 2013; Wandela, 2014). For the success of learner-centred teaching in Tanzanian contexts, which is important for nurturing students' interests in science, the education and training policy need to ensure the use of a sufficiently familiar language for science content learning, to facilitate students' abilities to discuss and respond to science lessons.

6.3.2 Inclusive science curriculum

Students' responses in group interviews disclosed that they were more interested in scientific aspects that were inclusive of their daily lives and cultures and those that were most clearly helpful to people and society. Students explained that they were interested in things like the effects of genetics on albinism and gender, which they saw as useful in solving problems linked with cultural beliefs. Also, students revealed in the interviews that they were more interested in scientific topics that were related with their contemporary, daily lives, such as environmental conservation, treatment of diseases and farming methods appropriate for environmental conservation. This finding suggests that, to make science interesting to the majority of students, the science curriculum needs to be inclusive of students' daily lives, contemporary issues, cultures and experiences. When science from the classroom links to students' cultures and experiences, it accommodates individual factors for students' interests, as suggested by my framework on intrinsic motivation (Anderman & Maehr, 1994). Students also suggested that, to make science interesting, teaching and learning resources like syllabi and textbooks need to include contextually relevant examples. The use of contextually relevant examples can enable learners to link science from the classroom to their real world in ways that facilitate meaningful learning (Scott et al., 2011) and are essential in nurturing students' interests in science (Eccles & Wigfield, 2002). Aikenhead (2006) disclosed that meaningful learning in science rarely happens because science is not regularly linked to students' everyday lives and thinking. Meaningful learning in science is limited by irrelevant science in schools. In Tanzanian contexts, specifically, Osaki (2004) noted that students can be learning fermentation and distillation industrial procedures in school completely detached from the local brewing happening in their communal contexts; in such circumstances, students cannot see the relevance of the science, even though the application is easily available. Local, scientific knowledge in African contexts, such as local brewing, traditional astronomy, traditional ways of farming, traditional herbalism and traditional arts and crafts, is useful, and accessing this knowledge can make science more inclusive, meaningful and interesting when these sources are integrated into the science curriculum (Asabere-Ameyaw, Dei, & Raheem, 2012; Osaki, 2004). These kinds of scientific local knowledge are linked to students' cultures and experiences. To facilitate meaningful science learning in Tanzanian contexts which is essential to foster students' interests in science, the science curriculum needs to be inclusive of students' daily lives and needs to clearly address contemporary issues related to students' cultures and experiences.

6.3.3 Involving learners' voices in teaching and learning activities

Students expressed, in the interviews for Article III, that scientific aspects were more interesting when the teaching and learning in the classroom engage students. According to students' responses, learning activities that gave learners active roles in science learning and make them interested in learning include the uses of hands-on activities, discussions, interactive approaches to teaching and real life examples. When students are engaged in discussion and in hands-on activities, students integrate their thinking and experiences in science learning and attain more meaningful learning. Hands-on activities and engaging teaching approaches like discussion can be situational factors for students' interests (Anderman & Maehr, 1994; Krapp, 2002); situation interest can mature to permanent interest in the subject (Krapp, 2002). Hands-on activities and discussions in science lessons can be fascinating learning experiences, as they engage learners actively in the lessons. The use of concrete and real life examples in science teaching helps students link science to the real world and can facilitate the kinds of meaningful learning (Scott et al., 2011) that are essential to create interest in the students. When the teacher connects science content to the learners' experiences, it can enhance students' interests (Osborne et al., 2003). Students' interests in scientific aspects linked to real life examples can be explained by the draw of meaningful learning. Anderhag et al. (2015) disclosed various approaches by teachers in science teaching to actively engage students in science learning and which supported students' interests in science. Such approaches involved acknowledging students' contributions in the lesson, engaging learners in active learning and making students aware of the objectives of the task. Learner-centred teaching approaches in science classrooms that enable learners to integrate their experiences, link science to their daily experiences, give learners active roles and acknowledge their contributions are essential for meaningful learning and for fostering students' interests in science.

7.0 Implications

This study aimed at investigating the realisation of learner-centred teaching in selected community secondary schools in Tanzania. Findings from the three studies have disclosed that learner-centred teaching is inadequately practised in the Tanzanian schools studied owing to various contextual challenges, including, among others, teacher' beliefs and knowledge with regards to the nature of scientific knowledge and inquiry-based science teaching, the use of an insufficiently practised language for instruction, contextual and classroom cultures that are not supportive of students' creativity and limited resources. However, the findings have also disclosed promising opportunities for the practice of learner-centred teaching approaches in the community secondary schools studied, which involve the use of open-ended questions that link science to students' daily lives, the use of locally available materials for generating students' investigations and the integration of a more familiar language during questioning and investigations. Improving teachers' training on the nature of scientific knowledge and inquiry-based teaching is very important to ensure the practice of learner-centred teaching in Tanzanian contexts. Teachers with knowledge of the nature of scientific knowledge can create a classroom setting that is conducive for students' creativity and engagements in critical thinking skills. No education system can achieve beyond the quality of its teachers (Ogunniyi & Rollnick, 2015). To facilitate appropriate learner-centred teaching in Tanzanian contexts, strengthening teacher training on the nature of scientific knowledge and inquiry is required.

The practice of inquiry-based science teaching is not confined to lab work, Other teaching approaches besides lab work can support students' engagements in inquiry (Crawford, 2014). Motivated and well-trained teachers can facilitate relevant, inquiry-based science teaching in places with limited resources (Hattingh et al., 2007). Questioning between the teachers and the students was disclosed by the findings of three studies as an approach that offers opportunities for inquiry-based science teaching. Teacher training on the use of questions of various levels can support students' engagements in critical thinking skills, which are an important element of learner-centred teaching. The use of investigative questions that are linked to students' daily lives and those aimed at tapping students' thinking and experiences can be useful for students' engagements with critical thinking skills. Teachers need training so that their questioning approaches will not solely focus on evaluation of students' attainments of scientific facts, and so they will, rather, assess students' disposition towards and acquisitions of critical thinking skills.

The use of locally available materials for generating students' investigations is an approach revealed by the three studies as offering potential for inquiry-based science teaching. When students are doing their investigations using resources in their communal contexts, they share more authority with their teacher in developing questions for investigation, designing investigations, collecting and interpreting data and communicating their findings (Ramnarain & de Beer, 2013). These kinds of investigation are, also, more authentic than traditional lab work (Braund & Reiss, 2006), and they can be useful for both under-resourced and well-resourced schools. Training teachers on the use of local contexts to generate students' investigations offers great potential for inquiry-based science teaching in community secondary schools. Teachers can give students a chance at thinking and developing their own investigations in their home and school contexts, which can facilitate students' engagements in the problem solving, application of science, backing claims with evidence and open-mindedness elements of critical thinking skills. More research on local scientific knowledge that can be linked into science curriculums is important for including learners' cultures and thinking and involving them in investigations. This involvement and engagement are important for the development of critical thinking skills and intrinsic motivation in science. Finally, more research, involving more Tanzanian schools, is important to further research the role of the language of instruction in science teaching for students' engagement in critical thinking skills.

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Appendices

Appendix 1: Teachers' interview guide.

1. Can you tell me the level of your education? (Diploma in education, Bachelor degree in education, Crash program certificate, other career apart from teaching).
2. For how long have you been teaching?
3. Which science subjects are you teaching currently in school?
4. How many science teachers are you in your school and in your department?
5. What motivated you to teach science subjects?
6. How is the status of science laboratories in your school?
7. Has the status of science laboratory in your school any impact on your preparation for quality practical work? How?
8. How is the support you are getting from school administration and other teachers in teaching practical work? Does it impact your preparation for experiments?
9. How would you explain the term inquiry based science learning and teaching?
10. Could you tell me of an interesting investigation you have been conducting with your students?
11. How did you choose such investigation?
12. Could you tell me how you prepared for that investigation?
13. What were the role of you as the teacher and the role of the students in that investigation?
14. What did you do for the opening and closing of that practical session?
15. What do you recommend as the best way of conducting an inquiry based science lesson?

Mwongozo wa majadiliano na waalimu
Maswali ya utangulizi

1. Naomba unieleze kiwango chako cha elimu (mfano stashahada, shahada, shahada ya uzamiri au shahada ya uzamivu).
2. Umefundisha kwa muda gani sasa?
3. Ni masomo gani ya sayansi unayoyafundisha sasa hapa shuleni?
4. Mpo walimu wangapi wa masomo ya sayansi idarani kwako na hapa shuleni kwa ujumla?
5. Nini kimekuvutia kufundisha masomo ya sayansi?
6. Unaweza ukaniambia hali ya maabara za sayansi hapa shuleni?
7. Unafikiri hali ya maabara hapa shuleni ina athari yoyote kwenye uandaaji wako wa majaribio ya kisayansi? Kivipi?
8. Unaweza ukalielezea jinsi uongozi wa shule na walimu wengine wanavyokuwezesha katika kufundisha majaribio ya sayansi? Unafikiri msaada wa uongozi wa shule una athari yoyote katika maandalizi yako ya majaribio ya sayansi?
9. Unaweza ukaelezea vipi kuhusu njia za udadisi katika kujifunza na kufundisha masomo ya sayansi?
10. Unaweza kunisimulia jaribio la kisayansi unalolipenda ambalo umewahi kuwafundisha wanafunzi wako?
11. Nini kilikuongoza kuchagua hilo jaribio la kisayansi?
12. Unaweza kunielezea jinsi ulivyofanya maandalizi ya jaribio hilo?
13. Katika hilo jaribio zipi ziilikuwa kazi zako kama mwalimu, zipi ilikuwa kazi za wanafunzi?
14. Nini kilifanyika wakati wa kuanza na wakati wa kuhitimisha hilo jaribio la kisayansi?
15. Wewe unashauri ni njia gani iliyo nzuri ya kufundisha jaribio la kisayansi kiudadisi?

Appendix 2: Group interview questions.

1. Tell me of anything you like or are interested in.
2. Can you tell me some examples of a practical or experiment you have been doing at school which you remember? Were you interested? Why?
3. What make you choose or not choose to study physics and chemistry?
4. Tell me of an interesting thing you have learned in any of the science subject. Why was it interesting?
5. What kind of activities you are enjoying doing in science lessons?
6. Tell me of a topic or aspects you have studied learn in any of the science subjects which you find boring or uninteresting. Why was it boring?
7. Can you tell me of aspects of physics, chemistry or biology you find difficult?
8. Tell me of an aspect of physics, chemistry or biology you find easy.
9. Tell me of anything you learn in science subjects that you are applying in your daily life. How?
10. What are you interested to do in future? How does it relate to science you learn in school?
11. Assume you were the science teacher, what would you do to make science interesting to students?

Maswali kwa ajili ya mahojiano na vikundi vya wanafunzi

1. Niambieni kitu chochote mkipendacho (mfano chakula, muziki, michezo, hadithi).
2. Mnaweza mkanisimulia mfano wa jaribio mojawapo la sayansi ambalo mmewahi kufanya hapa shuleni? mlilifurahia? Kwanini?
3. Nini kimesababisha uchague au usichague kusoma kemia na Fizikia?
4. Naomba mniambie kitu chochote mlichojifunza kwenye masomo ya sayansi ambacho mlikipenda au kukifurahia. Kwanini mlikipenda au kufurahia?
5. Ni kazi au shughuli gani mnapenda kufanya mnapokuwa mnajifunza masomo ya sayansi?
6. Niambieni mada yoyote ambayo mmeisoma katika masomo ya Kemia, Biolojia au Fizikia ambayo hamkuipenda. Mnafikiri kwa nini hamkuipenda?
7. Niambieni mada ambayo mliiona ngumu sana mlipoisoma katika Kemia, Biolojia au Fizikia. Mnafikiri kwa nini?
8. Niambieni mada ambayo mliiona rahisi sana mlipoisoma katika Kemia, Biolojia au Fizikia. Mnafikiri kwa nini?
9. Niambieni kitu chochote mlichojifunza katika masomo ya sayansi ambacho mnakitumia katika maisha yenu ya kilasiku. Kivipi?
10. Mnapenda kufanya kazi gani hapo baadaye? Kwa jinsi gani inahusiana na masomo ya sayansi mnayosoma kwa sasa hapa shuleni?.
11. Kama mngekuwa walimu wa sayansi mngefanya nini kufanya masomo ya sayansi yavutie au yapendwe na wanafunzi?

Appendix 3: Inductive and deductive categories used for data coding of teachers' interviews.

Themes	Categories	Sample Quotes
Contextual factors for the practice of inquiry-based science teaching	**Deductive categories**	
	Resource availability	'We do not have any laboratory but a class which we use for as a laboratory. We have few equipment which are not sufficient, therefore we do very few experiments' 'Also the laboratory is not enough for all students in the class. So the experiments are done in sessions. It is very difficult to allow every student to do the experiment alone. They have to do it in groups' 'In the time table there is no time for experiments, practical are being done in extra time'
	Inadequate teacher training	'Poor teachers' preparation'
	Language of instruction	'Our students are slow learners. This may be attributed to the fact that, they were using Swahili as a medium of instruction, switch to English it becomes a problem'
	Practical examination	'Sample examination question may be used as a guide for the experiment'.
	Concerns about students' safety	'I normally warned students not to touch or do anything before they have been told to do so'
	Inductive categories	
	Motivation to use local available materials	'We did the experiment on preparation of oxygen using manganese four oxide and hydrogen peroxide by using local available materials' 'I teach the experiment on a topic of osmosis using resources in our surroundings'
Levels of inquiry-based teaching	**Deductive categories**	
	Conducting activities	'Students have to perform experiments under the guidance of the teacher'
	Drawing conclusions	'At the end of the experiment, we did the discussion to see if the experiment was successful, if the result and the theory are in agreement, students are participating in discussions'
	Designing investigations	'In the rate of chemical reaction I give students a question outside the classroom…why do we put food in a refrigerator? (To avoid food spoilage, low temperature lower the rate of chemical reaction like food spoilage)'
	Asking questions	'We have creative students in our schools, who after doing what we have taught they may come up with their own investigation question'

Appendix 4: Categories from students' voices used for data coding of group interviews.

Theme	Categories	Examples of Quotes
Contextual challenges	Resource availability	'I am not studying physics because it has few teachers, when I study, I fail and get discouraged. I would have passed physics if we would have sufficient teachers and books'
	Language of instruction	'We cannot respond to questions although we understand them, we are not understanding the language'
	Teaching approaches	'I dislike separation of mixture, we did not do a single experiment, we studied it theoretically'
	Huge content	'Organic chemistry has many aspects'
Motivating factors	Helpful to the society	'Helps to eradicate bad beliefs'
	Hands-on activities	'No experiments' 'We did a number of experiments'
	Useful in daily life	'I like reproduction….It is about me'
	The use of discussion	'Also, the discussion can make someone understand something in detail...'
	Motivation from the teacher	'the teacher was asking questions when entering the class'
	Use of formative assessment	'I like doing regular exercises'
Motivating strategies suggested by students	Utilizing local resources for students' investigations	'I would have conducted experiment using things in our surroundings, like animals. This will enable the confirmation of the things studied theoretically'
	Utilizing discourse	'The one with a question have to ask the peers, and when they fail to get the answer they get help from the teacher'
	Integrating science teaching with students' experiences	'I would have use resources from the environment to facilitate understanding'
	Teaching what is relevant	'I would have omitted topics with no use in daily life, for example, volumetric analysis, I would have omitted it'
	Solving language problems	'The language to be use for content learning I wold have developed it from primary schools, whether English or Swahili'
	Improving teachers' training	'I would have introduced seminar to all science teachers. Teachers have to be trained, on science curriculum, ethics and how to monitor students' behaviours'

Errata list

On page V, line 4 .... ‘Mung’ corrected to ‘Mungu’
On page V line 10, ‘Ødeegard’ corected to ‘Ødegaard’
On page XI Line 21, ‘I observed 7’ corrected to ‘we observed 7’
On page 6 Line 7-8, ‘not yet operational’ corrected to ‘Not yet fully operational’
On page 6 Line 20-21, ‘Tanzania was colonised by Germany in the period 1886-1920’ corrected to ‘Tanganyika was colonised by Germany in the period 1886-1920’
On Page 6 Line 23, ‘During the British colonialism in Tanzania corrected to During the British colonialism in Tanganyika’