Supporting Licensed Science Teachers’ Professional Development in Adopting Learner-Centred Pedagogy in Tanzanian Secondary Schools

A thesis

submitted in fulfilment

of the requirements for the degree

of

Doctor of Philosophy

at

The University of Waikato

by

Vicent Naano Anney

THE UNIVERSITY OF WAIKATO

Te Whare Wānanga o Waikato

2013

Abstract

The purpose of this study was to obtain a better understanding of the professional learning needs of Tanzanian science teachers who were recruited using an alternative route approach to teacher recruitment and to seek ways to address these needs. The alternative route to teacher recruitment usually refers (but not always) to the enlistment of university graduates, who are trained in a non-accredited teacher education programme, and then licensed or certified to teach in schools. In Tanzania teachers trained in this way are referred to as 'licensed teachers'. This study first identified the licensed teachers' professional learning needs in relation to pedagogical content knowledge (PCK) by examining their effectiveness in using learner-centred teaching methods in the classroom. The findings from this first phase of the investigation revealed that the licensed science teachers rarely used learner-centred strategies and their PCK was underdeveloped in this area. In the second phase of the study a professional development intervention (PDI) was developed and implemented to enhance the licensed science teachers' PCK and improve their classroom teaching practices.

This study used a multiple case study approach underpinned by an interpretive research paradigm. The study adopted the situativity theory to inform the professional development intervention, with the view that teachers' learning and knowing are situated in and influenced by the physical and social context and participation in authentic activity as a community of learners. The participants of this study were six licensed teachers, twenty four students and five education officials. Data were collected from multiple sources such as classroom observations, one-to-one semi-structured interviews, focus group discussions, documentary reviews and teachers' reflective notes. The data were analysed thematically using the five components of PCK identified by Magnusson, Krajcik, and Borko (1999), as the analytical framework.

The results from the first phase of investigation showed that the licensed science teachers had underdeveloped PCK and did not use/understand learner-centred teaching methods. Instead their classroom teaching practices were dominated by teacher-centred teaching methods and they lacked the skills of preparing learner-centred science lessons. Also tests and examinations prepared by the licensed science teachers were found to be mostly testing the lower levels of Bloom's knowledge taxonomy, that is, knowledge, comprehension and application, with few items relating to analysis. The evaluation of the PDI indicated that it had a positive impact on licensed science teachers' PCK, with the licensed teachers showing improved classroom teaching practices after the PDI. Students' learning was enhanced as a direct result of licensed science teachers' improvement in their ability to design and teach lesson using learner-centred teaching methods.

This study has implications for teacher education practice and students' learning in countries using an alternative approach to teacher recruitment and for educational research. This thesis offers suggestions for reform in teacher education institutions, policy and practice and for further research into how to improve this form of alternative route to teacher recruitment. The most significant of these suggestions is the setting up of PLCs of teachers with on-going expert support and school leadership (headmasters/mistresses, district educational officers) involvement. This on-site structure for sustained, supported professional learning offers a way forward for improving PCK of many untrained licensed teachers currently working in Tanzanian rural community secondary schools. The thesis concludes that unqualified licensed science teachers working in schools need school-based professional development support to enhance their underdeveloped PCK, since students taught by licensed teachers are unlikely to be receiving the levels of knowledge and skills potentially needed to compete in the global economy.

Acknowledgements

This thesis is the result of valuable support and encouragement from many different individuals. I would first like to thank my chief supervisor Dr Anne C. Hume for her relentless support, advice, perseverance and encouragement in the production of this thesis. Her prompt and thorough feedback helped this difficult task to be completed on time. I also extend my thanks to my second supervisor Professor Richard K. Coll, for his timely feedback that shaped this thesis into the big picture. I feel grateful for having such a supervision team, who had confidence in me and in moments of doubt energized my work with their suggestions. I also appreciated my supervisors' generosity in accommodating me as part of their family during the lonely times of Easter, Christmas and New Year. Their generosity helped me to forget lonely moments away from my family and to focus on my thesis. Thank you very much for your kindness.

I would like to thank the University of Dar es Salaam World Bank project for their scholarship which covered various costs during the entire period of my study at the University of Waikato, New Zealand. Without this scholarship this study would not have been possible. Also, many thanks to Professor Yunus Mgaya, for his goodwill and support during the processing of my scholarship and Dr Eugenia Kafanabo for her timely processing of funds during the entire time of my study here in New Zealand.

Many thanks also go to the Ministry of Education and Vocational Training in Tanzania and all the Headmasters of Tlawi, Hewasi, Katani and Nungu (pseudonyms) secondary schools for their permission to allow me to conduct research in their institutions. Also I extend my thanks to all the science and mathematics teachers, education officers and students in these schools, who willingly participated in this study and appeared for interview and focus group discussion during data collection. I say God bless you abundantly.

I also extend my sincere thanks to my PhD colleagues and staff members at the Technology, Environmental, Mathematics and Science Education Research Centre for their moral and academic support. Many thanks to Dr Chris Eames, Associate Prof John Williams, Dr Karsten Zegwaard, Raewyn Oulton, Sue McCurdy, and Levinia Paku with whom I was able to build the social network and able to learn Kiwi culture. I also thank my office companion Nhung Hong, and my friend from Tanzania, Acluin Mwalongo, for their encouragement and sharing of research skills. My sincere thanks to Njuguna Karanja and Ernesta Mosha for their support during my study here in New Zealand.

Special thanks should go to my family, especially to my lovely wife Adelimarsi, my children, Philomena (Bei), Awe, Safari, and Naano, my father Naano Ae and my mother Bei Dawite, and my friends for their goodwill messages and prayers. I say thank you all. My wife Adelimarsi thank you very much for taking care of all family matters alone, in particular the special care you give my mother during her difficult time while I was away in the country during fieldwork and abroad in New Zealand. Your love, support, encouragement, commitment to our family, was my passion during writing of this thesis. I say thank you very much and God bless you. I also extend my sincere thanks to Baltzari Awe family and Frimin Silayo family for supporting my wife, in particular, during the difficulty time when my mother was critically sick and needs help to attend the treatment in various hospitals' in Tanzania.

I dedicate this thesis to my father Naano Ae and my mother Bei Dawite who gave me the opportunity to attend secondary school despite being discouraged by some community members that selling their cows to pay my secondary education fees was a waste of their resources. Their understanding, support, encouragement and commitment to my education made my future and I am proud of you my dad and mom, God bless you.

Publications from this thesis

Anney, V. N., Hume, A. C., & Coll, K. (2012, October). *The use of unqualified science teachers in developing countries: A barrier to achieving sustainable global education.* Paper presented at the Fourth Asian Conference on Education, Osaka, Japan.

Table of Contents

List of Figures

List of Tables

List of Appendices

Acronyms

MoEC	Ministry of Education and Culture
MoEVT	Ministry of Education and Vocational Training
OUT	Open University of Tanzania
PCK	Pedagogical Content Knowledge
PDI	Professional Development Intervention
PLC	Professional Learning Community
PLCs	Professional Learning Communities
UPE	Universal Primary Education

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 Overview

This chapter presents the background and rationale for the study. It begins with a brief outline of the researcher's personal background and interest in the current dilemma surrounding the global teacher shortage, which prompted education administrators in Tanzania to employ under-qualified/unqualified personnel as a way of overcoming the problem. A detailed outline of the rationale for the study is provided in the context of Tanzania including a statement of the research problem, the research objectives and key research questions guiding the investigation. The significance of the study is also discussed, followed by an overview of the thesis chapters.

1.2 Personal background and interest in this study

As the researcher in this study I developed the research interest in the plight of under-qualified/unqualified teachers as a result of personal experience before being trained and employed as a qualified physics and chemistry teacher in my home country of Tanzania. When I graduated from high school in 1995, I was asked by the headmaster of a newly built community secondary school in my village if I could help by teaching physics, chemistry and biology in his school, while waiting for my Advanced Certificate of Secondary Education Examination (ACSEE) results. I accepted his offer and felt it was a great opportunity for me to work in my village. When I reported for work at this community secondary school I met six other high school leavers who were temporarily employed and helping to teach students. However, I found the school had only two qualified teachers; the headmaster being one of them. I was allocated Form 1 physics, chemistry and biology classes to teach for seven months without any basic training in how to teach or about the teaching profession. Not surprisingly, I struggled to teach my subjects without any knowledge of education. After seven month of teaching I received my ACSEE results and applied to do further studies at Dar es Salaam

Teacher Training College doing a two-year Diploma course in teacher education majoring in physics and chemistry. During my holiday break from college I continued teaching in my village community secondary school because of the teacher shortage.

My pre-service teacher education training at Dar Es Salaam Diploma Teacher Education College helped me to acquire some knowledge of teaching and changed my perception of teaching and how to teach students. Indeed I have come to learn that when I was teaching as an unqualified teacher, I was transmitting knowledge and perpetuating rote learning in students. After graduating from college in 1999 I was employed in the same community secondary school where I taught for two years alongside unqualified high school leavers. This experience of teaching for two years as a qualified teacher also made me think that the unqualified high school leavers needed professional learning support in order to teach students well. With this experience in mind, I applied to the University of Dar Es Salaam for further studies in 2001, where I studied for a Bachelor of Education degree in science. I studied in the teacher education stream, majoring in chemistry and education and with biology as a secondary subject, with the intention of acquiring skills for teaching teachers. Also, I hoped to gain research skills that would be useful for understanding teaching. The knowledge and skills I acquired from university training helped me to understand the value of pre-service teacher education training before becoming involved in classroom teaching. I became even more aware that the current informally employed high school leavers in community secondary schools need professional support.

In 2005, the Tanzanian Government started mass employment of high school leavers in community secondary schools to overcome the shortage of teachers caused by the impact of increased primary education enrolment that created more demand for secondary education. At this time I had just finished my Bachelor of Education degree in science. This Government action disturbed me greatly since my previous experience of working with licensed science teachers informed me that they lacked sufficient expertise to teach effectively. I felt that this problem needed to be addressed and I considered that research might provide the answers. Therefore, in 2005 I decided to do further teacher education study at postgraduate level to improve my skills in research and understanding of teacher education. In 2006, I was employed as a tutorial assistant in the department of curriculum and teaching in the Faculty of Education, University of Dar Es Salaam, and my role was supervising student seminars in the science education teaching methods courses.

As part of my Masters of Education research, I conducted a research project into the ‘use of locally improvised teaching materials as an alternative strategy for improving chemistry teaching in community secondary schools in Tanzania’ (Anney, 2007), which involved both qualified teachers and unqualified high school leavers in interviews, focus group discussion and classroom observation. During classroom observations I learned that most unqualified high school teachers were facing many challenges in teaching sciences in their classrooms, in particular, their inability to invoke clear arguments about student learning difficulties, and develop good instructional strategies and student activities (Bozkurt & Osman, 2008). The classroom observation findings in my Master’s research project and the government’s decision to formalize the employment of high school leavers as teachers motivated me to immerse myself in an in-depth investigation of strategies for tackling these teachers’ professional learning needs. As a qualified science teacher, trained first at diploma level for two years, with two years’ teaching experience, and four years of training at bachelor level and one year of teaching internship, I felt that high school education level did not provide sufficient knowledge for carrying out effective classroom teaching. Also, working as a teacher education tutor at university for two years deepened my understanding of teacher education practices and the teaching profession as a whole. Building on these experiences I developed an increased interest in teacher education and in particular how to improve the teaching skills and knowledge of unqualified high school leavers teaching in our Tanzanian secondary schools. Therefore, I am hopeful the findings from this study will inform policy makers about the need for professional learning support for these untrained teachers in my country Tanzania and elsewhere.

1.3 Background to the study

A shortage of qualified teachers is a serious problem affecting the provision of quality education not just in Tanzania but worldwide. Recent studies have reported an inadequate supply of qualified teachers internationally and in particular for expanding elementary and secondary education systems in many developing countries (Fyfe, 2007; Ingersoll, 1999; Lonsdale & Ingvarson, 2003). This global shortage of teachers is thought to be aggravated by a number of factors, such as: the inability of teacher education institutions to train enough teachers; the aging teaching population; the high turnover rate of teaching staff; the increased rate of pupil enrolment; the unattractiveness of teaching as a career compared to other careers; teachers' low pay; poor working conditions; weak school governance; frequent curriculum changes; and assessment procedures that put more demands on teachers (Ingersoll, 2002; Lonsdale & Ingvarson, 2003; Santiago, 2002). While teacher shortage is considered a global phenomenon, the lack of qualified teachers is far more acute in developing countries, in particular Southern Asia and much of Africa (Fyfe, 2007; Millward, 2006). According to Millward (2006) and (Pandey, 2009), Sub-Saharan Africa alone needs almost four million new teachers to fill the available positions in schools by 2015 for the growing education sector. The recent work by Audrey-marie and DeStefano (2008) reported on the shortage of teachers from six Sub-Saharan countries (Ghana, Kenya, Uganda, Malawi, Senegal and Zambia) to illustrate the magnitude of the shortage of secondary schools teachers in Sub-Saharan Africa. They found that by 2015, these six Sub-Saharan African countries will need approximately 391,711 new teachers to meet the demand of the growing secondary education sector. Tanzania, like other Sub-Saharan African countries is not immune to the current crisis of teacher shortage in secondary schools. For example, the study by Lujara, Kissaka, Trojer, and Mvungi (2006) found that urban Tanzanian secondary schools have a 60% shortfall of qualified science and mathematics teachers, while rural secondary schools have an 80% shortfall of qualified science and mathematics teachers.

To address the shortfall in teachers, governments in different countries have responded by adopting both long-term and short-term strategies. Commonly used strategies include: alternative routes of entry into the teaching profession or licensing under-qualified/unqualified candidates; improving working conditions to attract qualified teachers who have retired from teaching; using a distance learning approach; and developing special loans and scholarships for those entering the teaching profession from other fields (Conner, 2009; Even & Leslau, 2010; Santiago, 2002). Of these options, the alternative route of entry/licensing under-qualified candidates into the teaching profession is the most popular short-term strategy that is widely used in both developing and developed countries to increase teacher numbers. Alternative routes to teacher recruitment usually (but not always) refer to the recruitment of university graduates, who are then licensed or certified to teach in schools without being trained in an accredited teacher education (long-term) programme (Heine, 2006; Legler, 2002). However, in numerous developing countries many alternative route teachers do not even have a bachelor's degree.

Alternative route teachers in Tanzania are referred to as 'licensed teachers', crash programme teachers' or 'vodafaster' teachers (Editor, 2010; O-saki, 2007). 'Vodafaster' is a colloquial word referring to the cheapest way to top up a mobile phone in Tanzania, using Voda, one of the network suppliers. Some of the teachers recruited through these alternative routes receive a short induction course in teaching methods before they start teaching in the classroom. In this study these teachers will be referred to as licensed teachers. In Tanzania licensed teachers are provided with four weeks of training to introduce them to the basics of classroom teaching without any actual classroom orientation. Generally, alternative routes recruitment is "an approach to licensing teachers that bypassed the more traditional route of completing a professional course of study in a teacher training institution" (Fenstermacher, 1990, p. 156). Thus, the approach allows individuals who have not studied at accredited teacher education colleges/universities to enter the teaching profession.

Educational policy makers are in a dilemma about the best structure for alternative routes for teacher recruitment since there are disputed research findings between proponents and opponents of the approach (Darling-Hammond, 2000a; Mitchell & Romero, 2010; Sorensen, Young, & Mandzuk, 2005). Mitchell and Romero

(2010) summarise the opponents' argument: "alternative certification is a watered-down teacher preparation programme that places ill-prepared and under-qualified, or unqualified, teachers in our nation's classrooms" (p. 364). In contrast, proponents of alternative routes teacher recruitment claim that "these programs fundamentally restructured teacher training and are far superior to traditional teacher training...unlocking university monopolies over teacher education—monopolies that believe offer too little practical content" like (Mitchell & Romero, 2010, p. 364).

Available studies on alternative routes to teacher recruitment are mainly evaluative (Cohen-Vogel & Smith, 2007; Grubbs, 2009; Salyer, 2003); with many studies focusing on comparing the effectiveness of alternative route teachers in classrooms teaching with traditional teachers (Darling-Hammond, Chung, & Frelow, 2002; Fetler, 1999). Other studies have examined the effects of alternative route teachers on student achievement (Darling-Hammond, Berry, & Thoreson, 2001; Goldhaber & Brewer, 2000; Nunnery, Kaplan, Owings, & Pribesh, 2010), while some have determined the characteristics of an effective alternative route teacher recruitment programme (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008).

Studies examining the practice of early career teachers generally suggest that most novice teachers and under-qualified alternative route teachers lack "an understanding of pedagogy, instructional strategies, classroom management, and students' social and academic developmental issues" (Nagy & Wang, 2007, p. 99). Under-qualified/unqualified teachers in particular face a challenging teaching environment, in particular how best to teach students with different abilities and interests (Kardos & Johnson, 2010). Not surprisingly, a substantial body of literature has reported that highly skilled and qualified teachers are more effective in the classroom, and help students to learn better (Aaronson, Barrow, & Sander, 2007; Haycock, 1998; National Middle School Association, 2004; Rockoff, 2003; Wright, Horn, & Sanders, 1997). The ability of any teacher to do well in teaching depends not only on pre-service training, but also on the availability of extensive and effective professional support, such as in-service training and on-going professional learning in the school settings (Adams & Krockover, 1997; Nagy &

Wang, 2007). Such professional development opportunities are considered the best way to increase teachers' effectiveness in the classroom. Therefore, on-going professional learning would appear to be an ideal approach for supporting under-qualified licensed science teachers working in various community secondary schools in Tanzania, as their pedagogy and content knowledge arguably needs to be improved.

Shulman (1987) maintained that the ability of teachers to effectively use different teaching methods, learning theories and principles to transform students' understanding and develop their skills, depends on their professional knowledge base for teaching. He identified a number of knowledge categories that comprised this knowledge base: content knowledge; general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge (PCK), knowledge of learners; knowledge of educational context; and knowledge of educational ends (Shulman, 1986, 1987). Of all these categories according to Shulman (1987) PCK is

> of special interest because it identifies the distinctive bodies of knowledge of teaching … represents a blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction. (Shulman, 1987, p. 8)

In order to become a teacher using the traditional path, pre-service teacher education is intended to develop the content knowledge and pedagogical knowledge of teacher-trainees (Etkina, 2010). Since pre-service teacher training, professional development, and teaching experience are considered key sources for building teachers' PCK (Etkina, 2010; Grossman, Schoenfeld, & Lee, 2005; Hume, 2010; Loughran, Berry, & Mulhall, 2006), it seems likely that licensed science teachers recruited via non-traditional university-based approach without undergoing pre-service teacher training have will underdeveloped PCK. This deduction implies that novice licensed science teachers employed without pre-service teacher training would benefit from professional learning support to develop their PCK. Remarkably, there is little evidence in the literature about strategies for supporting the PCK development of alternative route teachers such as those already deployed in Tanzanian secondary schools. Indeed, much of the research on alternative certification programmes fails to delineate the professional learning needs of the alternative route licensed teachers overall. This present study thus sets out to investigate the professional learning needs of alternative route licensed teachers and to identify possible strategies for supporting the growth in PCK of licensed science teachers in Tanzanian secondary schools. The next sections describe the study context and Tanzania's education system.

1.3.1 Context of the study

The United Republic of Tanzania was formed out of the union of two sovereign states, namely the Republic of Tanganyika and Peoples Republic of Zanzibar, on 26th April, 1964. Tanzania is located in East Africa covering an area of 945,087 km^2, the 12th largest of the 54 countries of Africa. It is surrounded by Mozambique, Malawi and Zambia to the south; the Indian Ocean in the east; the Democratic Republic Congo, Burundi and Rwanda in the west; and Kenya and Uganda to the North (Figure 1).

Figure 1: *The map of Tanzania showing its location in Africa*

Source: http://www.afdb.org/en/countries/east-africa/tanzania/

Dodoma is the Tanzanian capital city and the decision to move the capital from Dar es Salaam to Dodoma was made in 1973. While the national assembly has moved to Dodoma, many government officers are still in Dar es Salaam, which is the largest commercial city in Tanzania. Tanzania has a population of 45 million, comprising more than 120 different tribes each speaking different vernacular languages but united by the language of Kiswahili as the (lingua franca) medium of communication (National Bureau of Stastics, 2012). The vernacular language is the first language that a child learns at home and its use remains at the family level. Kiswahili is the medium of instruction in pre-primary and primary schools, while English is the medium of instruction in secondary schools and tertiary education (Kitta, 2004). A few Asian and European communities make up less than one per cent of the population.

Eighty per cent of Tanzania's population live in rural areas and are dependent on small-scale crop cultivation, while a few pastoral communities depend on animal farming. Recently, the mining and tourism sectors have been making a greater contribution to the national gross domestic product. However, Tanzania is considered a poor nation by all international indicators of poverty, and 80% of the population in rural areas live on less than one US dollar a day, which is below the international poverty line of $1.25 (United Republic of Tanzania, 2009). The per capita income in 2009/2010 was $560 and the percentage of households living in abject poverty in 2007 reached 33.7% (Mkulo, 2010). In 1967, Tanzania carried out many social, economic and political reforms in an attempt to eradicate the three main barriers to human development: poverty, ignorance and disease. A major political reform that has influenced people's lives in Tanzania and its education system was the '*Policy of Socialism and Education for Self Reliance*' in 1967, when the government nationalized private property and education and health services were made universally free. As a result of this socialist policy, Tanzania achieved 85% enrolment of its primary school-aged pupils through the Universal Primary Education (UPE) campaign in the 1970s, which was a massive campaign to ensure free primary education for all school-aged children. Adult education was also introduced for children above school age and for adult people who missed out on primary education before independence.

In the mid-1980s, an economic crisis prompted the Tanzanian Government to introduce liberal economic reforms required by the World Bank and the International Monetary Fund (Vavrus & Moshi, 2009). These reforms were designed to stimulate the stagnant economy, caused by a socialist policy that prohibited foreign and private investment. A direct result of this liberal economic reform was the introduction of cost sharing in social services—education was no longer free, and parents had to pay for their children's education. This economic reform caused an immediate drop in the enrolment rate in primary schools from the previously achieved 85%, to 56% in 2003 (Kitta, 2004). The drop in student enrolment prompted the Tanzanian Government to think of ways to address the problem, and so in 1995 it introduced two key policy documents: the *Tanzania Development Vision 2025*, and the *Education and Training Policy* (ETP), which stipulated that:

> A good system of education in any country must be effective in two fronts: *on the quantitative level,* to ensure access to education and equity in the distribution and allocation of resources ... and, *on the qualitative level*, to ensure the country produces the skills needed for rapid social and economic development. (Ministry of Education and Culture, 1995, p. i)

In addition, the *Development Vision 2025* also recommended that Tanzania's "education system should be restructured and transformed qualitatively with focus on creativity and problem solving" (United Republic of Tanzania, 1999, p. 19). Adding to these Tanzanian Government efforts, in 1999, the World Bank and International Monetary Fund introduced a debt relief programme for 'Highly Indebted Poor Countries' (HIPC) where the "eligible countries prepare a Poverty Reduction Strategy Paper (PRSP) that spells out how the government will redirect money that would have gone to debt servicing toward areas like education and health" (Vavrus & Moshi, 2009, p. 33). The Tanzanian Government as one of the beneficiaries of this programme decided to redirect debt servicing money into improving primary education and it introduced the *Primary Education Development Plan* (PEDP) after it was accepted by World Bank and International Monetary Fund. The PEDP was launched in 2001 and school fee was abolished in public primary schools. As a result, the primary school enrolment rate jumped from 54.1% in 1990 to 97.2% in 2008. Also, pupils' transition rate from primary to secondary schools grew from 3.4% in 1984 to 56.7% in 2008, such that the number of students who needed secondary education also rose (Ministry of Education and Vocational Training, 2008a). In turn, these changes created a demand for more secondary schools to cater for the increased numbers of pupils graduating from primary schools across the country, which led to a shortage of teachers in secondary schools.

To support these reforms, in 2005 the Tanzanian government reviewed the 1997 version of the science and mathematics curriculum and introduced a learner-centred curriculum in secondary schools. The 1997 science education curriculum was reviewed because of identified weaknesses such as: a curriculum overloaded with content rather than student learning activities; teaching approaches that advocated a teacher-centred pedagogy; students' learning competencies and activities not well identified; and a curriculum not geared to a constructivism theory of learning (Chonjo, O-saki, Mrutu, & Possi, 1996; Ministry of Education and Vocational Training, 2007). To address these issues, a new learner-centred science education curriculum was introduced built on the constructivist perspective. The central principle of constructivism is that learning is an active process, and therefore learners actively participate in the construction of knowledge rather than being passive receivers of knowledge (Mayer, 2004; McCombs, 2003; Mtika & Gates, 2010; Tam, 2000; Tynjälä, 1999; Wheatley, 1991). The constructivism perspective suggests that the role of teachers in the classroom is to facilitate student learning by supporting students' construction of knowledge.

1.3.2 The structure of Tanzania's present education system

Tanzania, as a former British protectorate, maintains an education system, whose structure is very similar to the English education system that it inherited many years ago. The education system is hierarchical and formal; it is composed of pre-primary, primary, secondary and tertiary education, as well as teacher education and vocational training. Children attend two years of pre-primary education between the ages of 4-6, mostly in urban areas because pre-primary education is not well established in Tanzania and there is no government funding for it.

Students then attend seven years of compulsory primary education from the ages of 7-13, and upon completion about 56% are able to join secondary schools (Omari & Anney, 2008). These students attend four years of ordinary (junior) secondary education from the ages of 14-17, after which they sit the Certificate of Secondary Education Examination (CSEE) in nine subjects. Students who perform well in division[1] one and two, and a few from division three in the CSEE attend two years of advanced (senior) secondary education, after which they sit the Advanced Certificate of Secondary Education Examination (ACSEE) in four subjects. On graduation, students are able to join a tertiary institution which takes three to five more years of study, depending on the programme of specialization (Figure 2). However, for higher tertiary education studies, only students with divisions one and two in ACSEE are eligible for a loan from the government for their university studies. Students with division three are eligible to study at a university but they have to pay the tuition fees and all related study costs themselves, or with the help of their parents. Finally, students with division four, or who fail, join the private sector or become self-employed.

1.3.3 Pre-service teacher education in Tanzania

Most formal teacher education in Tanzania is undertaken using college-based or university-based teacher education models (Meena, 2009). The college-based model in this study refers to training that occurs in non-tertiary institutions which are not accredited to offer bachelor degrees, while the university-based model refers to tertiary institutions of education accredited to offer bachelor and higher degrees. The college-based model awards qualifications to two cadres of teachers: the Grade A Certificate of Teacher Education for pre-primary and primary schools teachers, and the Diploma Certificate in Teacher Education for teaching ordinary level (junior) secondary schools (Figure 2). The Grade A Certificate of Teacher Education involves a two-year residential programme designed to recruit

[1]Division one, is awarded to a candidates who pass in at least seven subjects with grades A-C, in at least four subjects, and reach an aggregate of 7-17 points; division two, is awarded to candidates who pass in at least seven subjects, with grades A-C, in at least four subjects; and reach an aggregate of 18-21 points; division three is awarded to candidates who pass in three subjects with grades A-D, and reach an aggregate of 21-25; and division four is awarded to candidate who pass in at least two subjects, and reach an aggregate of 26-34 points; and division zero (failed) is awarded to candidate who fail all seven. The aggregate criteria: A=1 point, B=2 points, C=3 Points, D=4 points F=5 points

candidates who have completed ordinary (junior) level secondary schooling and passed the grade 'A' Certificate of Teacher Education Examination. These grade 'A' certificate teachers usually go on to teach pre-primary and primary school pupils. The Diploma Certificate in Teacher Education is also a two-year residential programme and candidates are initially recruited after passing ACSEE.

According to the Tanzanian *Education and Training Policy*, teachers with a Diploma in Education are qualified to teach Forms 1 and 2 only and Forms 3-6 are to be taught by university graduate teachers (Meena, 2009). However, the shortage of teachers' means there may be diploma teachers and unqualified licensed Form 6 leavers teaching students in Forms 1-4 in Government community secondary schools in Tanzania.

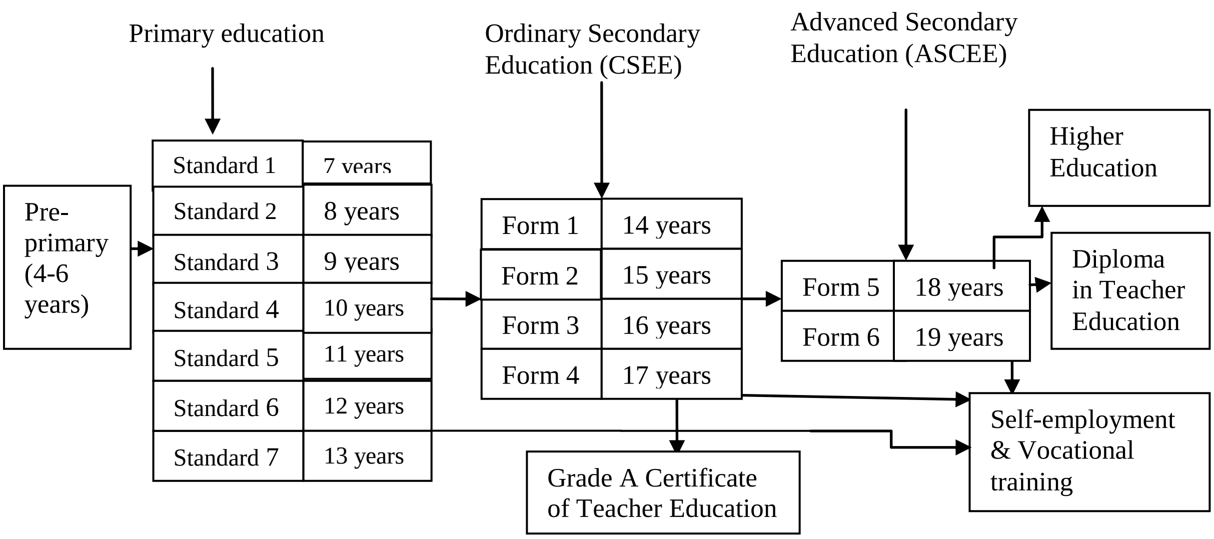

Figure 2*: Tanzanian education structure*

In contrast, the university-based teacher education programme offers a three-year bachelor degree course in different science and arts disciplines. The universities train two cadres of teachers: the *Bachelor of Education degree in Arts or Science* (BEd Science or BEd Arts) where pre-service teacher major or specialize in one teaching subject either in Science or Arts and major in teacher education courses; and the *Bachelor of Education degree with Arts or Science* (BAEd or BScEd), where pre-service teachers study two teaching subjects, either Science or Arts, with the education course as a minor subject. Bachelor of Education degree graduates are employed in teacher education colleges to teach teachers, and are referred to as *teacher education stream teachers,* while Bachelor of Education degree (with Arts or Science) graduates are employed to teach secondary school students, and they are referred to as the *secondary education teacher stream* in Tanzania.

1.4 Rationale for the study

The Tanzanian Government first recruited alternative route teachers back in the mid-1970s by selecting untrained Standard 7 leavers (Primary school leavers) to teach in primary schools to address the shortage caused by the introduction of the Universal Primary Education (UPE) programme. According to Omari, Mbise, Mahenge, Malekela, and Besha (1983), these Standard 7 leavers were primary-school leavers (Grade 7 students) aged 13-15, who were trained in a four-month induction course and then licensed to teach in primary schools. A second group of alternative route teachers were Form 6 (high school) leavers who were recruited in 2005 through the ‘crash programme approach’ and trained for four weeks before being licensed to teach in secondary schools. These crash programme teachers in Tanzanian secondary schools are Form 6 students with lower grades in ACSEE examination results, below the university admission cut-off point (Wedgwood, 2007). Due to their lower ACSEE grades, which do not allow them to be enrolled directly in universities, the Tanzanian Government proposed that these teachers would upgrade their qualification through the Open University of Tanzania distance learning courses and would receive school-based professional development support.

Both these groups of teachers could be considered unqualified because their induction courses are not sufficient for building a knowledge base for teaching, particularly content knowledge and pedagogical knowledge. Such licensed teachers with inadequate content knowledge and pedagogical knowledge concern many education experts (Geeves & Bredenberg, 2005; O-saki, 2008; Shaban, 2007), and there is evidence these concerns are well founded. Recently Sydney (2008) reported a high dropout rate for licensed teachers upgrading to degree level via open distance learning at the Open University of Tanzania, and likewise, Komba and Nkumbi (2008) observed that in Tanzanian secondary schools professional learning activities for enhancing teachers' skills and knowledge are inadequate. The number of students failing in CSEE has been increasing year after year (Table 1), and 2010 was the climax of their poor performance in the history of secondary education in Tanzania, as only 11.50% of students passed with divisions one to three, and 49.60% of students totally failed the final examination. The use of under-qualified/unqualified licensed teachers is already appearing to affect the status of the Tanzanian education sector, particularly the currently booming secondary education sector. The poor performance of students in the CSEE over the three consecutive years of 2008, 2009, and 2010 since the massive employment of unqualified licensed teachers in Tanzanian secondary schools is alarming and a reason for the nation to rethink its teacher education practices (Table 1).

Table 1: *Showing students passes and fail rate CSEE by percentage*

Year	(%) of student passed by division				(%) of failed students	Total number of students
	I	II	III	IV		
2004	4.8	8.4	24.6	53.7	8.5	63487
2005	5.2	6.5	21.5	55.7	10.7	85292
2006	4.5	6.9	24.3	53.4	10.9	85865
2007	5.1	8.6	21.9	54.7	9.7	125288
2008	3.5	6.4	16.8	56.9	16.3	163855
2009	1.8	4.2	11.3	52.6	30.1	248336
2010	1.5	2.9	7.1	38.9	49.6	310826

Source: Ministry of Education and Vocational Training 2010

The growing number of students failing the national examination is a clear indicator of the challenges ahead of Tanzania as a nation trying to achieve *Development Vision 2025*, which envisages that by 2025 Tanzania will:

> ...be a nation with a high quality of education at all levels; a nation which produces the quantity and quality of educated people sufficiently equipped with the requisite knowledge to solve society's problems, meet the

> challenges of development and attain competitiveness at regional and global levels. (United Republic of Tanzania, 1999, p. 5)

The Tanzanian *Development Vision 2025* suggests that education will be a strategic agent for achieving its vision, as it posits that "education should be treated as a strategic agent for mindset transformation and for the creation of a well-educated nation" (United Republic of Tanzania, 1999, p. 19). In addition, the recently revised Tanzania *Education Sector Development Programme* (ESDP) sees that education as conduit for achieving the vision 2025 of well-educated citizens and the tool for ousting abject poverty in Tanzania by 2025. The ESDP:

> …envisages the creation of a well-educated nation with a high quality of life for all…total transformation of the education sector into an efficient … outcome/output based system…for achieving the educational goals expressed in Tanzania's Development Vision 2025 … within the overall aim of poverty reduction through educational provision improvement. (Ministry of Education and Vocational Training, 2008b, p. vii)

Despite the dream that the education sector is considered a means for achieving Tanzania's *Development Vision 2025*, clearly education in Tanzania is not achieving this expected outcome. Secondary school students' failure rate is increasing, despite the government's intention of transforming the education sector so that it will take a pivotal role in poverty reduction and hence improvement in the quality of life. As a result of their weak academic backgrounds and lack of experience in teaching internship, licensed science teachers are likely to be the cause of the drop in achievement. In many developing countries systems, drastic increases in student numbers usually lead to drop in pass rate, yet often number of passes still increases (see Table 1). Since the upgrading to degree level and professional training programmes put in place for these licensed teachers is not working as intended, and it is impractical to remove these teachers from schools because of the shortage of trained teachers, research is necessary to help address this difficult scenario. The research needs to investigate how to develop these teachers' PCK while they continue working and teaching at community secondary schools and such research is probably best done through school-based professional learning activities. Therefore, this study hopes to document evidence and inform policy makers and educational experts about the likely negative impact of employing unqualified/untrained teachers in the Tanzanian education system on present and future generations. Hopefully it will also provide evidence of the way forward.

1.5 Statement of the research problem

Various studies have shown that there is a positive association between students' high levels of achievement and teachers who are well qualified academically with deep content knowledge in their specific subjects and strong pedagogical knowledge (Alton-Lee, 2003; Dee & Cohodes, 2008; Goldhaber & Brewer, 1997, 2000; Hill, Rowan, & Ball, 2005; Monk, 1994; Monk & King, 1994; Rockoff, 2003; Stronge, Ward, & Grant, 2011; Wayne & Youngs, 2003; Zuzovsky, 2011). For example, students taught by well trained teachers have been found to have higher achievement scores in science and mathematics (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Clotfelter, Ladd, & Vigdor, 2010; Darling-Hammond & Youngs, 2002; Rivkin, Hanushek, & Kain, 2005), while students taught by under-qualified or uncertified teachers' have been found to have lower achievement scores in science and mathematics (Darling-Hammond, 2000c; Goldhaber, 2002; Monk, 1994; Stronge et al., 2011). Many Tanzanian community secondary schools are staffed by unqualified teachers because of an inadequate supply of qualified teachers (Lihaya, 2009; Mwaipopo, 2010), and this situation has resulted in poor performances by students with most students only achieving Division Four in the CSEE or completely failing (Ministry of Education and Vocational Training, 2010).

Students in schools staffed with unqualified licensed teachers have lost interest in studying science subjects (Lihaya, 2009), because of poor classroom teaching approaches dominated by teacher-centred methods (Ministry of Education and Vocational Training, 2010). Ministry of Education and Vocational Training officials claim that poor performance "in science subjects has, in turn, resulted in an avoidance syndrome, with most students choosing to enrol in social science/arts subjects, rather than natural sciences" (2010, p. vii). A recent study by Mfuru (2010), investigating the quality of teaching and learning of unqualified teachers in Tanzanian secondary schools, reported that many unqualified licensed teachers were found to have inadequate content knowledge, pedagogical knowledge and the inability to translate the science syllabus into appropriate learning tasks for students. He suggested that unqualified licensed teachers needed professional development in content knowledge, pedagogy, and the skills for interpreting the curriculum and selecting teaching and learning materials. Poor student performance in Tanzanian secondary schools appears to be directly linked to teaching by unqualified teachers with inadequate content knowledge and pedagogical knowledge. Therefore, this research seeks to examine and identify the professional learning needs of unqualified/untrained licensed science teachers in Tanzanian secondary schools and meet their needs by developing and implementing an appropriate professional development intervention (PDI).

1.6 Study objectives

The aim of this study was to investigate the classroom practice of unqualified ‘licensed science teachers’ recruited through the alternative route to teacher recruitment in Tanzania secondary schools. The study involved examination and identification of the licensed teachers’ professional learning needs and the challenges facing them in the teaching of the learner-centred curriculum in Tanzanian secondary schools. The study also developed and implemented a professional development intervention (PDI) programme for addressing some of the licensed science teachers’ identified professional learning needs. To achieve these aims the study had the following specific research objectives:

i. To explore and identify the professional learning needs, particularly those relating to the PCK of licensed science teachers in Tanzania.
ii. To examine the effectiveness of the classroom practice of Tanzanian licensed science teachers when teaching science using learner-centred instruction
iii. To identify and examine the constraints and strengths of the current professional development programmes for supporting Tanzanian licensed science teachers in community secondary schools

iv. To identify the factors that enhance professional learning in the context of Tanzanian community secondary schools.
v. To develop, implement and evaluate a PDI for supporting licensed science teachers in community secondary schools in Tanzania.

1.6.1 Research questions

To achieve the objectives outlined above the study attempted to answer the following questions:

i. What are the professional learning needs, including those relating to PCK, of licensed science teachers in Tanzania?
ii. How effective are Tanzanian licensed science teachers in teaching science using learner-centred instruction?
iii. How do Tanzanian licensed science teachers perceive their current professional development programmes?
iv. What factors could facilitate the sustainable establishment of professional learning communities of licensed science teachers in Tanzania?
v. How did licensed science teachers in Tanzania perceive the effectiveness of the PDI developed and implemented in this study?
vi. How effective was the implemented PDI in meeting licensed teachers' professional learning needs?

1.7 Significance of the study

Very little research has been undertaken into the support of teachers recruited via the alternative route approach in Tanzania and Sub-Saharan Africa. This study can potentially make several contributions to an improvement in the alternative route teacher recruitment approach. For example, the findings of this study should help policy-makers and educational experts to develop and implement appropriate professional development interventions for licensed teachers (alternative route teachers) in Tanzania and sub-Saharan African countries. As Horn (2002) commented, the purpose of educational research is to "inform policy decisions and support political objectives of special interest within and outside the educational community" (p. 161).

The results should also help educational administrators and managers to judge the effectiveness of alternative route teachers in the classroom and their likely impact on student learning outcomes. Potentially, the results of this present study should help educational experts to understand the PCK constraints of licensed science teachers when teaching in the classroom. Finally, the study could help to improve the practice of science education at classroom level and become a tool for poverty reduction by improving the quality of the education provided to present and future generations of Tanzanians.

1.8 The structure of the thesis

This study is organized into seven chapters. Chapter 1 outlines the background and context of the study, and a statement of the research problem, study objectives, research questions, and significance of the study. It establishes the need for a study into licensed science teachers' professional learning needs. The review of literature regarding the study is presented in chapter 2 and chapter 3 outlines the research methodology. Chapter 4 presents the results of the study, in particular the PCK needs of licensed science teachers and challenges facing licensed science teachers in teaching science using the learner-centred curriculum, and their classroom practice and beliefs. Chapter 5 presents the findings from the PDI and teachers' views on it. Chapter 6 discusses the findings and interpretation of the study. Chapter 7 presents the implications, limitation and conclusions of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature relating to the research questions for this study. First, the importance of qualified teachers for student achievement is established followed by the characteristics of effective teachers, including possession of pedagogical content knowledge (PCK), practices promoting learner-centred education, and the need for professional development to improve teacher quality. To inform teacher education in developing countries the principles of effective professional development are identified, and current professional development models are critically examined. The review then focuses on the debate surrounding the practices of alternative routes to teacher recruitment internationally and the experience of such practices in Tanzania. Current provisions for the professional development of teachers recruited through alternative routes in Tanzania are described.

2.2 Quality education as a basic right for all citizens

Education is recognized worldwide as a basic human right, with education for every child as one of the priorities on the agenda of the international community. Article 28 of United Nations Convention on the Rights of the Child (United Nations Education Scientific and Cultural Organization, 2007) argues for "the right to education on the basis of equality of opportunity. This right needs to be realized through the provision of compulsory and free primary education, and available and accessible secondary education" (p. 118). Numerous developing countries like Tanzania have ratified such international conventions on education for all, including the *Jomtien World Declaration on Education for All* in 1990, followed 10 years later by the *Dakar Framework of Action for Education for All* and the *United Nations Millennium Development Goals* (MDGs) in 2000. All these conventions require developing countries to achieve universal primary education by 2015 with at least 75% of their young population having access to quality secondary education (United Nations Education Scientific and Cultural

Organization, 1990, 2000, 2007). Countries that have ratified such international conventions promoting education for all thus now have an obligation to ensure the availability of quality education to every child, and this obligation has prompted governments worldwide, in particular developing countries, to invest more resources in educating their citizens.

Quality education is recognized worldwide as a key factor in realizing individual and society transformation. Advocates for quality education maintain that it enables citizens to be more successful and productive in this era of industrial innovation and high technology. For example, Fantini (1980) argued that "a well-educated citizenry is vital to today's advanced industrial society. Its continued advancement is measured in fact by the quality of the education its citizens enjoy" (p. 324), while Jenlink (2004) asserts that education is "responsible for preparing the society's children to enter the social structures of society…educational system, schools and colleges are charged with educating future citizens so each individual may assume responsibility as an active member of the society" (p. 329). Education reduces social inequalities in society (H. Levin, Belfield, Muennig, & Rouse, 2004), because "only educated citizens can achieve economic growth and this requires equalized access to quality education, now more than ever" (Education International, 2009, p. 4), quality education helps the person to acquire skills and knowledge for control of his own life (Fantini, 1980).

The term 'quality education' is universally accepted and used widely by educational professionals and non-professionals alike, although it has numerous meanings and lacks a single clear definition. Many definitions of quality education found in the literature are context specific and many depend on who is defining quality education. However, there is consensus in the literature about the dimensions of quality education. These dimensions include:

- learners who are healthy, well-nourished and ready to participate and learn, and supported in learning by their families and communities;
- environments that are healthy, safe, protective and gender-sensitive, and provide adequate resources and facilities;
- relevant content that is reflected in curricula and materials for the acquisition of basic skills, especially in the areas of literacy, numeracy and

skills for life, and knowledge in such areas as gender, health, nutrition, HIV/AIDS prevention and peace;

- processes through which trained teachers use child-centred teaching approaches in well-managed classrooms and schools and skilful assessment to facilitate learning and reduce disparities; and
- outcomes that encompass knowledge, skills and attitudes, and are linked to national goals for education and positive participation in society. (Rasheed, 2000, p. 3)

However, despite the recognition that quality education is a key factor in transforming society, many developing countries are struggling to provide such education for their citizens. In most developing countries achieving quality education is not an easy task because of barriers, such an inadequate budget for financing education, large class sizes, and inadequate supply of qualified teachers (H. Levin et al., 2004; United Nations Education Scientific and Cultural Organization, 2007). For numerous developed and developing countries to achieve the dream of quality education for their citizens the most challenging of these factors is the lack of qualified teachers (Chapman & Adams, 2002; Education International, 2009, 2011), because teachers are increasingly identified as key players in achieving quality education (Darling-Hammond, 2000c). Article 69 of the Dakar Framework of Action states that:

> Teachers are essential players in promoting quality education, whether in schools or in more flexible community based programmes; they are advocates for, and catalysts of, change. No education reform is likely to succeed without the active participation and ownership of teachers. (United Nations Education Scientific and Cultural Organization, 2000, p. 20)

Education International (2009) states that “if you want to improve educational quality, improve the quality of teachers” (p. 10). A quality teacher has particular attributes, which include: mastery of content knowledge, understanding of pedagogical knowledge, knowledge of learners, curriculum knowledge, teaching experience and leadership skills (Rasheed, 2000). Such attributes are believed to impact positively the quality of education and student achievement (Darling-

Hammond, 2000c; Randall, 2008; Shulman, 1987), as will be discussed in the next section.

2.3 Impact of teacher quality on student achievement

Many school variables influencing student achievement, such as class size, socio-economic status, years of teaching experience, certification, subject specialization, highest degree, teacher's field of study in the college/university, instructional methods, teacher's characteristics and others, have been studied to determine what influence they have on student achievement (Hattie, 2003; Public Policy Institute of California, 2003; Rivkin et al., 2005; Wright et al., 1997). The debate on which school variables have more influence on student achievement has been intense for many years among educational researchers but there are strong indications that quality teachers are the key variable that determines students achievement in schools more than any other variable (Aaronson et al., 2007; Hattie, 2003; Hill et al., 2005; Rockoff, 2003; Wright et al., 1997). Wright et al. (1997) observed that "teacher effects are the dominant factor affecting student academic gain and that the classroom context variables of heterogeneity among students and class sizes have relatively little influence on academic gain" (p. 57). These effects, be they positive or negative, can be long lived, observes Haycock (1998): "Indeed, even two years after the fact, the performance of fifth-grade students is still affected by the quality of their third-grade teachers" (p. 6). In a similar vein Aaronson et al. (2007) added that teacher quality positively affects slow learners and lower-ability students' academic achievement in the classroom.

The view that teachers are a key factor that influences students' achievements in schools is also reported in studies such as the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) (Akiba, LeTendre, & Scribner, 2007; Beese & Xin Liang, 2010; Organisation for Economic Co-operation and Development, 2010). For example, TIMSS studies by Akiba et al. (2007) reported that students taught by qualified teachers have higher achievement in mathematics than those taught by less qualified teachers. Similarly, PISA found that highly qualified teachers have a positive impact on students' achievement in science (Beese & Xin Liang, 2010).

Thus, the evidence from the literature clearly indicates that teacher quality matters when it comes to student achievement and school improvement (Stronge et al., 2011; Whitehurst, 2002). So, what is meant by quality teaching and what attributes does a quality teacher exhibit? The next section discusses the attributes of an effective teacher.

2.4 Generic attributes of effective teachers

There are many conceptions of teacher effectiveness and defining teacher effectiveness is a complex task (Calabria, 1960; Goe, Bell, & Little, 2008). Over 50 years ago Calabria (1960) reviewed the findings of various studies on teacher effectiveness and concluded that the "characteristics which make a teacher effective form a complex of many interrelated variables requiring a multidisciplined approach in research" (p. 92). He also claimed that what constitutes an effective teacher depends on one's interpretation and each teacher brings into the classroom his/her own natural personality, behaviour and learned skills (Steele, 2010). Some authors argue that teacher effectiveness can be evaluated on the basis of gains in student academic achievement. For example, Kupermintz (2003) claims that "a teacher whose students achieve larger gains is the effective teacher" (p. 289), while Goe et al. (2008) state that effectiveness "refers to a teacher's ability to improve student learning as measured by student gains on standardized achievement tests" (p. 5). These views imply that student academic achievement or performance is a useful gauge of teacher effectiveness.

The literature identifies many general attributes of an effective teacher (Calabria, 1960; Clark & Walsh, 2002; Kupermintz, 2003; McCall, 2008; McEwan, 2010; Stronge, 2007; Stronge, Tucker, & Hindman, 2004); however, most fall into three main categories, that is, a teacher's personal qualities, teaching traits, and academic qualities or intellectual traits (McCall, 2008; McEwan, 2010). The attributes relating to the personal qualities of an effective teacher include being:

- mission-driven and passionate about teaching and helping students to learn (Calabria, 1960; McCall, 2008; McEwan, 2002, 2010);

- generous with personal time for students, caring for students deeply, having a sense of humour, with empathy and respect for students and parents (McCall, 2008; Stronge et al., 2004);
- skilled in leadership with high creativity (McEwan, 2002; Stronge, 2007);
- focused on students' deep learning, with good verbal ability and excellent understanding of language of instruction (Haberman, 2004b; Loughran, 2010; Walls, Nardi, von Minden, & Hoffman, 2002);
- believable and authentic, admitting their mistakes and learning from students (Fabry, 2010; S. Thompson, Greer, & Greer, 2004);
- appreciative of students' effort and well organized in and out of the classroom (Gurney, 2007; Stronge et al., 2004); and
- a good listener when students experience problems, and understanding students' behaviour (Gurney, 2007; Haberman, 2004b).

The attributes that are related to teaching traits or professional qualities include the ability to:

- facilitate co-operation in the classroom (Vasquez, 2008 ; R. C. Wilson, Dienst, & Watson, 1973);
- use different teaching methods (Alton-Lee, 2003; McEwan, 2010; Muijs & Reynolds, 2011);
- use pedagogical skills appropriate to the learning environment and specific subject discipline (Hattie, 2003; McCall, 2008);
- engage students in activities and manage time (Hattie, 2003; McEwan, 2010);
- exhibit motivation and dedication to his/her students and his/her job, and have excellence in instructional methods (McEwan, 2010; Muijs & Reynolds, 2011; Walls et al., 2002);
- use broad personal knowledge to develop strong relationships with students and understanding of individual student learning difficulties and the ethics of teaching (Haberman, 2004b; Hattie, 2003; McEwan, 2010);
- relate what she/he is teaching to the lives of the students (Alton-Lee, 2003; S. Thompson et al., 2004);

- evaluate individual student progress, work in collaboration with other teachers (Hattie, 2003; McEwan, 2010); and
- share institutional goals with other teachers and recognize the complexities of teaching (McEwan, 2010).

The academic attributes of an effective teacher include having:

- deep mastery of subject matter knowledge and understanding of pedagogical knowledge and have strong academic qualification (Dana, Campbell, & Lunetta, 1997; Whitehurst, 2002);
- high literacy level and has knowledge of the educational context (McCall, 2008; Randall, 2008); and
- high level of cognitive ability such as ability to guide student metacognition and strategic learning, to be reflective, communicative and responsive to students needs and the demands of teaching profession (Clark & Walsh, 2002; McCall, 2008; McEwan, 2010; Randall, 2008).

Although these generic attributes learned from the literature are generally possessed by most effective teachers of all subject disciplines, some studies have reported that teacher effectiveness is discipline specific (McCall, 2008; Muijs, Campbell, Kyriakides, & Robinson, 2005). This specificity means that different disciplines require unique and specific instructional strategies. Thus, effective science teachers possess some different attributes from teachers of other disciplines (Lennartsson, 1997; McCall, 2008). For example, Brendzel (2005) pointed out that teaching science requires knowledge of participatory activities that involve students in processes such observing, measuring, classifying, recording data and report writing—things that are not common to other disciplines such as the social sciences. These specific science teaching-related attributes of effective teachers can be identified from the literature (Çimer, 2007; Trowbridge, Bybee, & Carlson-Powell, 2004; Vasquez, 2008 ; Woolnough, 1994; Yager, Hidayat, & Penick, 1988). Such science teachers:

- are scientifically literate, are knowledgeable about their science subject and are lifelong learners;
- are competent, and enthusiastic in their subject and in the classroom;

- help students to develop their own potential by recognizing personal meaning in teaching and learning;
- recognize students' prior knowledge and science misconceptions during teaching;
- provide opportunities for students to test their ideas, use a variety of instructional methods, have high expectations of themselves and their students, and create an environment conducive for student learning and teaching;
- encourage cooperative learning among students, effectively assess student progress and provide correct feedback on time;
- use learner-centred teaching approaches; and
- accommodate students' individual needs, such as cultural, cognitive and developmental.

These attributes are considered significant and exclusive to effective science and mathematics teaching. The literature on effective teaching generally agrees that for teachers to teach science effectively they need have developed substantial knowledge in their understanding of: the science content knowledge to be taught; educational theory and practice, broader general knowledge of education and PCK (Dana et al., 1997; Shulman, 1986; Ware, 1992). Of these knowledge bases PCK is considered by many observers to be crucial for teacher's effectiveness in the classroom (Lederman & Gess-Newsome, 1992; Loughran & Berry, 2010; Shulman, 1987). This observation implies that effective science teachers need to be rich in PCK in order to transform classroom teaching for the benefits of learners.

2.5 PCK as a knowledge category for teaching

PCK is considered a unique category of professional knowledge for teachers (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009; Hume & Berry, 2011; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008). This category of knowledge according to Shulman (1987) is the knowledge "which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (p. 9), and differentiates teachers from subject specialists. He elaborated that PCK “represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (Shulman, 1987, p. 7). Lederman and Gess-Newsome (1992) viewed PCK as the professional knowledge used by practicing classroom teachers in organizing, managing, elaborating, demonstrating and presenting the subject matter more comprehensively to learners.

In his original publication on the topic, Shulman (1986) identified two knowledge components of PCK: knowledge of forms of representations of ideas which include illustrations, examples, explanations and demonstrations that teachers use to make the subject matter understandable to the learners; and knowledge of students such as understanding of their learning difficulties and dealing with students’ misconceptions because students bring their incorrect scientific ideas into the classroom. Since the Shulman publication, many other attributes and interpretations of PCK have emerged and its components have been expanded upon (Loughran, Mulhall, & Berry, 2004; Magnusson et al., 1999; Marks, 1990; Van Driel, Verloop, & de Vos, 1998). For example, Magnusson et al. (1999) extended Shulman’s ideas and proposed five components of PCK for science teaching. These are: orientation towards science teaching; knowledge and beliefs about the science curriculum; knowledge and beliefs about assessment in science; knowledge of students’ understanding of science; knowledge and beliefs about instructional strategies for science teaching.

Though PCK is perceived differently by many writers, it remains an accepted and useful academic construct in teacher education (Hume & Berry, 2011; Lederman & Gess-Newsome, 1992; Schneider & Plasman, 2011; Van Driel & Berry, 2012). Most educational scholars agree that PCK is elusive in nature, and as such is a hidden concept or tacit form knowledge. Thus, knowing exactly what PCK comprises during lesson preparation and teaching is a difficult task for teachers (Kind, 2009). Hume (2010) agrees that understanding PCK is a complex task and describes the complexity of the nature of PCK in teaching:

> ...it is a very difficult form of knowledge to tie down and exemplify because teaching is a complex and challenging activity that requires on-going and

> informed decision-making in response to an individual students learning needs. It tends to be a fluid entity, constantly changing and evolving as classroom circumstances dictate. (p. 29)

Therefore, PCK is a form of teachers' professional knowledge that is very personal, topic specific and situational (Van Driel & Berry, 2012), and built up over time usually after many years of experience in teaching (De Jong & Van Driel, 2004; Hume & Berry, 2011; Van Driel et al., 1998). For example, work by Van Driel et al. (1998) suggests that teaching experience is "the major source of PCK, whereas adequate subject-matter knowledge appears to be a prerequisite" (p. 673). Howey and Grossman (1989) outlined key sources of teachers PCK: first, specific subject content knowledge training such as physics, biology and chemistry; secondly, internship experience by teacher trainee teaching particular subjects; thirdly, teachers education training in courses relating to teacher education subject-specific components such as instructional methods, curriculum, and psychology; and, finally, attending specific courses or workshops during teacher education. Recent studies have reported that pre-service teachers trained through Content Representation (CoRe) design have been able to develop a tentative PCK (Hume, 2010; Hume & Berry, 2011, 2013). Apart from CoRe studies, Nezvalová (2011) also found that pre-service teachers taught using an action research approach have acquired some basics of PCK, in particular, knowledge of students' conceptions, understanding students learning difficulties and instructional strategies. However, De Jong and Van Driel (2004) cautioned that pre-service teacher education is inadequate to address all components of PCK development. Thus, teachers can begin to acquire the basics of PCK first in pre-service training, but it can only develop through work experience. There is much evidence in the literature suggesting that teacher's participation in professional development training or in-service training programmes helps to improve their PCK development (Adams & Krockover, 1997; du Plessis & Muzaffar, 2010; Loucks-Horsley & Matsumoto, 1999; Van Driel & Berry, 2012).

The nature and extent of a teacher's PCK can be reported in a continuum form from weak to strong (Gardner & New-Gesssome, 2011), and because of its continuum nature the components of PCK can be enhanced using teachers' participation in professional development and reflective practice, and studying high quality learning materials (Gess-Newsome, Cardenas, & Austin, 2011; Y.-C. Lee, 2011). Penso (2002) and Loucks-Horsley and Matsumoto (1999) claimed that teachers with weak or limited PCK tend to: teach more factual science knowledge instead of enhancing student understanding of scientific concepts; they lack adequate skills to focus on science main ideas suggested in the topic; they highly depend on textbooks and teachers' guides as their main teaching resource, their diagnostic strategies for evaluating students' learning difficulties, preconceptions and misconceptions are weak and they employ non-interactive teaching methods. Due to the continuum nature of PCK some studies (e.g. Gardner & New-Gesssome, 2011; E. Lee et al., 2007; Park et al., 2011) developed have developed rubrics that are used to measure teachers' PCK. These PCK rubrics indicate that teachers with weak PCK:

- do not acknowledge students' prior knowledge or include them in their lesson plans;
- have lesson plans with little or limited consideration of variations in students' learning approaches and they habitually use one teaching instruction approach;
- have limited understanding of students' learning difficulties and make no attempt to address students' learning difficulties;
- generally verify the previous lesson covered and direct students how to study in the new lesson but without the essentials features of inquiry-based teaching; and,
- use representations such as examples, illustrations, models and analogies that are ineffective, irrelevant and scientifically inaccurate or not linked to students' prior experiences (Gardner & New-Gesssome, 2011; E. Lee et al., 2007; Park et al., 2011).

On other hand teachers with strong PCK:

- draw up their lesson plan and content based upon students' lesson content is built upon students' prior knowledge;

- acknowledge variations in students' approaches to learning and provide diverse opportunities for students' to engage their own learning strategies;
- consider students' learning difficulties as a core aspect of their lesson planning and address them during the lesson;
- adopt all essential features of inquiry-based teaching such as engaging learners in scientific oriented questions, and requiring learners to provide evidence in responding to questions (e.g. learners formulate explanations from evidence; learners connect explanations to scientific knowledge and communicate and justify explanations (National Research Council, 2000); and,
- use representations that are pedagogically effective, scientifically accurate and connected to students' prior knowledge (Gardner & New-Gesssome, 2011; E. Lee et al., 2007; National Research Council, 2000; Park et al., 2011).

Vavrus, Thomas, and Bartlett (2011) reported that teacher's expertise such as content knowledge without PCK has little impact on student learning because teachers' ability to transform subject content knowledge into understandable student learning outcomes depends on the level of their PCK development. They also reported that teachers with highly developed PCK were reported to display more learner-centred pedagogy. Vavrus et al. (2011, p. 75) argued that teachers' ability to use "learner-centred pedagogy is a critical element in the development of teachers' and tutors' PCK because student learning depends on it to a large extent". Thus, teachers who demonstrated the use of learner-centred instructional strategies effectively in their classrooms settings are considered to have a developed PCK. The potential of learner-centred education as a recent education reform in developing countries is discussed in section 2.6 in details.

2.5.1 Relationship between subject content/matter knowledge and PCK

The terms *content knowledge* and *subject matter knowledge* are interchangeably used in science education literature (e.g., Berry, Loughran, & Van Driel, 2008; Even, 1993; Gess-Newsome, 2002; Magnusson et al., 1999; Shulman, 1986, 1987;

Van Driel et al., 1998) by teacher education researchers, although these terms have different connotation in science education. For example, according to Krauss, Neubrand, Blum, and Baumert (2008) the term content knowledge "describes a teacher's understanding of the structures of his or her subject" (p. 2); likewise, Koehler and Mishra (2009) defined content knowledge as "knowledge about the actual subject matter that is to be learned or taught" (p. 63) to the learners. On other hand, According to Casey (2008) subject matter knowledge is the "amount and organization of knowledge in the mind [of teacher], including knowledge that something is true and why it is true" (p. 21). In addition, Sperandeo-Mineo, Fazio, and Tarantino (2006) described subject matter knowledge as a "teacher's quantity, quality and organisation of information, conceptualisations and underlying constructs in a given field of science (e.g., physics)" (p. 236). According to Cochran and Jones (1998) subject matter knowledge is an umbrella conception that has four components: *content knowledge* - which is refer to the facts and concepts of the subject matter; *substantive knowledge* - this is the philosophy that guide the field (science field); *syntactic knowledge* - is the methods and processes by which new knowledge is generated in a certain particular field; and *beliefs about subject matter* - this refer to students' and teachers' feelings in relation to particular subject matter. Nilsson (2008) claimed that "traditionally, teachers' subject matter knowledge could be considered as equating with the number of courses he/she has taken in the subject, or the amount of teaching experience he/she has in the subject" (p. 1284). Therefore, for consistency in this thesis subject matter knowledge is defined as teacher's broader understanding of content of his/her teaching subject (such as physics, biology chemistry and mathematics), how new knowledge is generated, philosophy that guide science teaching including their beliefs about science teaching. Therefore, elsewhere in this thesis whenever the term content knowledge was used it implies the broader description provided in the work of Cochran and Jones (1998).

Previous studies consistently agree existing relationship between subject matter knowledge and PCK in classroom teaching (Geddis, 1993; Tamir, 1988; Usak, Ozden, & Eilks, 2011). Shulman (1987) hypothesized that teacher's use PCK to transform subject matter knowledge into the forms that are easily accessible to students. Likewise, Geddis, Onslow, Beynon, and Oesch (1993) argued that PCK "as knowledge that plays a role in transforming subject matter into forms that are more accessible to students" (p. 582). In a recent work, Borowski et al. (2011) claimed that "depth of content knowledge is a precursor to PCK … depth of content knowledge providing [provide] initial support for the PCK construct" (p. 9). Teachers who are rich in subject matter knowledge display more PCK because their deep understanding of subject matter knowledge provides wider flexibility of using different innovative teaching strategies in the classroom (Rollnick et al., 2008). According to Van Driel et al. (1998) PCK as a knowledge base of teaching is used by teachers to transform the:

> "…subject matter knowledge, so that it can be used effectively and flexibly in the communication process between teachers and learners during classroom practice … when dealing with subject matter, teachers' actions will be determined to a large extent by their PCK, making PCK an essential component of craft knowledge. (p. 675)

In other words during teaching of subject matter (physics, biology or chemistry) teachers' classroom manifestation are determined by his/her level of PCK. Teachers deep understanding subject matter knowledge is inevitably important and a prerequisite for development of teachers PCK (Magnusson et al., 1999; Rollnick et al., 2008; Van Driel et al., 1998). Literature (e.g. Borowski et al., 2011; Park, Jang, Chen, & Jung, 2011) explicitly agrees on prerequisite of subject matter knowledge in manifestation of teachers PCK because "transformation of subject matter knowledge for the purposes of teaching is the heart of PCK" (Park et al., 2011, p. 248).

2.6 Learner-centred education curriculum reform in developing countries

Many countries in Sub-Sahara Africa in the mid-1990s went through educational reforms that focused on improving the quality of education and student learning by incorporating elements of learner-centred education in the school curriculum (Kitta & Tilya, 2010; Vavrus et al., 2011). As part of this reform movement Tanzania reviewed its secondary and teacher education curriculum and introduced a learner-centred education curriculum. The major purpose of the curriculum review in Tanzania was to address the problem of classroom teaching that was dominated by teacher-centred teaching methods instead of learner-centred teaching methods (Kitta & Tilya, 2010; Ministry of Education and Culture, 2005; Tanzania Institute of Education, 2009). For example, the Tanzania Ministry of Education and Vocational Training (MoEVT) in its various policy documents such as *Secondary Education Development Programme* II (SEDP II) and *Education Sector Development Plan* (ESDP) admitted that many schools suffer from "poor teaching approaches in the classroom, as it is teacher-centred, with students relying heavily on the teacher and old notes" (Ministry of Education and Vocational Training, 2010, p. v).

The Ministry also observed that students' performance was significantly affected by a "lack of learner-friendly pedagogy" (Ministry of Education and Vocational Training, 2008c, p. 51). Likewise, newly published science and mathematics syllabuses put more emphasis on the use of learner-centred teaching methods and suggested classroom teaching should involve students as active learners. For example, the introductory note section the physics syllabus published in 2005 clearly delineated that "the teaching and learning strategies using this reviewed syllabus should be student-centred and activity oriented" (Ministry of Education and Culture, 2005, p. iii). A similar statement was also included in the chemistry syllabus published in 2007, noting that the reviewed syllabus "encourages the constructivist approaches whereby the learners participate actively in the construction and acquisition of knowledge" (Ministry of Education and Vocational Training, 2007, p. ii). This secondary education curriculum reform was also integrated into teacher education curriculums such as the Diploma in

Education Physics syllabus published in 2009, where it was stated that the syllabus “intends to provide student-teacher with broad knowledge on understanding basic important issues on education such as learner-centred teaching approach …” (Tanzania Institute of Education, 2009, p. 2).

Despite the supposed adoption of a learner-centred pedagogy in many developing countries, in particular Tanzania and other Sub-Sahara Africa nations, research is currently inconclusive about the effectiveness of learner-centred pedagogy in the classroom, and the meaning of the learner-centred education. Many terms are used when referring to learner-centred education. Some terms include: student-centred method, child-centred, progressive teaching, participatory teaching, transformative teaching, tender-minded or ‘soft’ pedagogy, client-centred teaching method, learner-centred instruction, discovery method, self-directed learning, and others (Baeten, Kyndt, Struyven, & Dochy, 2010; Mayer, 2004; Nkhoma, 2002; Pillay, 2002; Spencer & Jordan, 1999; Tabulawa, 2003). Paris and Combs (2006) argued that as a result of this ambiguity surrounding learner-centeredness, “the term is used freely and without definition, suggesting that the meaning is shared and unproblematic” (p. 572). They further argued that because of the many names associated with the notion of learner-centredness it is difficult for any education expert to communicate its meaning “effectively within and outside the educational community and [this] makes us vulnerable to co-option of the term by those who would vilify it or use it to political advantage” (p. 572). Lea, Stephenson, and Troy (2003) commented that because of the current inconsistency in defining learner-centred education it has resulted in an overabundance of synonyms. The following examples of terms and definition reported in the literature exemplify the fluidity of the learner-centred education concept:

- student-centred pedagogy “being [focussed] on changes in students’ learning and on what students do to achieve this rather than on what the teacher does” (Harden & Crosby, 2000, p. 335);
- Learner-centred education defined as “a form of active learning where students are engaged and involved in what they are studying” (J. Brown, 2008, p. 30);
- learner-centred education defined as “the perspective that couples a focus on individual learners (their heredity, experiences, perspectives,

backgrounds, talents, interest, capacities, and needs) with a focus on learning (the best available knowledge about learning and how it occurs and about teaching practices that are most effective in promoting the highest levels of motivation, learning, and achievement for all learners". (McCombs & Whisler, 1997, p. 9); and

- learner-centred pedagogy defined as "a foundation for clarifying what is needed to create positive learning contexts to increase the likelihood that more students will experience success" (Harkema & Schout, 2008, p. 517).

These definitions, however, imply that in learner-centred education the learner is the key focus of the learning process, the main focus of teaching is the facilitating of student learning, with students actively constructing their own knowledge (Chiang, Chapman, & Elder, 2010), and the teacher's role is then that of a facilitator of student learning (O'Sullivan, 2004; Weimer, 2002). Pillay (2002) contended that the "most commonly mentioned attributes of learner-centred education is that it considers learners' needs to be central to the design and delivery of instruction" (p. 93). Other authors have argued that in processes of learner-centred instruction the main focus of teaching is that of facilitation of students' understanding and learning, rather than covering of the content of the subject or syllabus (G. Brown, 2004; Chiang et al., 2010; Norman & Spohrer, 1996; Weimer, 2002).

Constructivist learning theory is believed to be the origin of learner-centred education (Baeten et al., 2010; Harkema & Schout, 2008; Schunk, 2012; Tabulawa, 2003), while others attributed it to the original work of prominent educational scholars and philosophers such Jean Piaget, John Dewey, Lev Vygotsky, Carl Rogers, and Jacques Rousseau (Chisholm & Leyendecker, 2008; Cornelius-White, 2007; Tabulawa, 2003). According to constructivist theorists, "teachers should not teach in the traditional sense of delivering instruction to a group of students. Rather, they should structure situations such that learners become actively involved with the content through manipulation of materials and social interaction" (Schunk, 2012, p. 231). The major assumption drawn from the constructivist theory of learning by learner-centred pioneers is that "learning is an active process in which learners are active sense makers who seek to build coherent and organized knowledge" (Mayer, 2004, p. 14). According to Carter (2010) learner-centred pedagogies share the following tenets of constructivism: student intellectual freedom and autonomy of creativity; democratic decision making in knowledge construction; and high degrees of tolerance and flexibility during the learning engagement process. Other studies suggest that in a learner-centred education there is a total paradigm shift from teaching to student learning (Kitta & Tilya, 2010; Liu, Qiao, & Liu, 2006).

Weimer (2002) proposed five key changes that she says must occur if teaching is to be more learner-centred: first, the balance of power between the teacher and students shifts to an egalitarian relationship, where teachers allow students to make some of the decisions in and out of the classroom; second, the purpose of teaching lesson content usually changes from that of covering content to promoting students' knowledge, skills and awareness of content; third, the role of the teacher should change from that of presenting information and the content to that of sharing some decisions such as planning learning experiences and guiding learners; fourth, the responsibility for learning belongs to students, so that they can understand their strengths and weaknesses; and finally, the purpose and process of evaluation should go beyond assigning grades to the promotion of individual student learning. Weimer (2002) argued that if teaching instruction reflects these five key features of a learner-centred approach the results is positive student learning outcomes.

Learner-centred teaching methods are widely accepted in the literature as better teaching methods than teacher-centred teaching approaches (O'Neill, 1991), which disseminate rote learning through passive classroom interactions (Jessop & Penny, 1998; O'Sullivan, 2004). The advocates of learner-centred teaching methods justify a learner-centred pedagogy saying it improves student learning outcomes and is a more effective teaching method compared to teacher-centred pedagogies (Kitta & Tilya, 2010; Tabulawa, 2003). Other studies reported that when students are taught using the learner-centred teaching approach they develop a spirit of motivation that results in deeper, durable knowledge and mere transferable skills than traditional teacher-centred teaching methods like lecture and recitation (Schmitt, Hu, & Bachrach, 2008; Walczyk & Ramsey, 2003).

Learner-centred teaching pedagogy promotes students participation in classroom, it engages students in real world experience and supports the development of students' higher order thinking including cognitive, metacognitive, and performance skills (de la Sablonnière, Taylor, & Sadykova, 2009; J. Thompson, Licklider, & Jungst, 2003). Importantly, learner-centred pedagogy allows teachers to evaluate students actual skills set in the criteria of the lesson (de la Sablonnière et al., 2009).

Despite adoption of a learner-centred education curriculum by developing countries, some scholars in developing countries consider learner-centred education as a Western construct promoting Western values (Chisholm & Leyendecker, 2008; O'Sullivan, 2004; Schweisfurth, 2011), and advocated by education aid donors such as the World Bank and the International Monetary Fund as a 'carrot and stick' motivation for supporting educational reforms in developing countries (Carter, 2010; Tabulawa, 2003). Although the recent curriculum reforms in many developing countries put more emphasis on the use of learner-centred teaching methods than traditional teacher-centred methods as an panacea for students low achievements in schools, Carter (2010) cautioned the pioneers of learner-centred education that "learner-centred pedagogies are in danger of becoming a one-size-fits-all approach in a neo-liberal world irrespective of issues of diversity and cultural context" (p. 223). He further argued that because of diversity in terms of values and philosophy that underpin learner-centred practices, it does not necessarily work in every educational context (Carter, 2010). Despite the adoption of learner-centred education curricula in many countries, numerous challenges in the implementation of a learner-centred education have been reported in the literature. Previous studies identified some inhibiting factors such as: a lack of the resources needed to implement learner-centred approaches; teachers' and students' beliefs systems; and teachers' inadequate understanding of the learner-centred teaching methods affecting the implementations of the learner-centred education in many countries (Nykiel-Herbert, 2004; O'Neill & McMahon, 2005; Schweisfurth, 2011; Sikoyo, 2010). Another underlying problem facing teachers in implementing learner-centred education is the difficulties of a paradigm shift for most teachers from summative assessment regimes to formative assessment techniques because of their long experience of being used to summative assessment approach (Kitta & Tilya, 2010; Nykiel-Herbert, 2004; Schweisfurth, 2011). Additionally, teachers' beliefs, values, attitudes and background experience, where teacher-centred approaches were used to teach them in secondary school and teacher training colleges, may make it difficult for these teachers to reorient their practices from a teacher-centred to a learner-centred approach (O'Sullivan, 2004; Tabulawa, 2003). Teachers' resistance to change is also a barrier to the implementation of learner-centred education as teachers in South Africa, even after attending professional development workshops about learner-centred pedagogy, were found to be not implementing learner-centred practices in their classrooms (Rogan & Grayson, 2003). Brodie, Lelliott, and Davis (2002) observed that teachers' "prior qualifications, reflective competence, grade level, subject knowledge and confidence, as well as access to resources and support structures in their schools, are all implicated in their take-up of learner-centred practices" (p. 556.).

Studies also reported that pupils who have experienced a more teacher-centred approach consider a learner-centred approach as more demanding for them and sometimes they resist using it (O'Neill & McMahon, 2005). If a learner-centred approach is not well planned, it results in student frustration, particularly during discussions where students can get confused, resulting in poor student learning outcomes (Wohlfarth, Sheras, Simon, Pimentel, & Gabel, 2008). Specifically, the challenges facing Tanzanian teachers include: inadequate knowledge of how to teach a learner-centred curriculum because of the limited nation-wide in-service training conducted before the adoption of the new learner-centred curriculum; lack of support for new teachers; inadequate teaching and learning materials; and overcrowded classrooms (Kitta & Tilya, 2010). Tanzanian teachers were also reported to lack the appropriate skills for developing and using learner-centred assessment techniques, in particular formative assessment skills (Kitta & Tilya, 2010). Kitta and Tilya (2010) observed that the main factor for teachers to unsuccessfully change their assessment regime from summative to formative assessment is because of the mismatch between the curriculum and assessment approaches, whereby the Government introduced an academic curriculum, while maintaining a content-driven external examination regime and this forces teachers to teach so students pass examinations.

Despite the popularity of learner-centred education, critics argue that it puts more emphasis on individual learners (O'Neill & McMahon, 2005), and it takes away teachers' professional autonomy (O'Neill, 1991). Pillay (2002) suggested that for learner-centred education to be effectively implemented and have a significant impact on student achievement, teachers' and students' beliefs need to be transformed first. Teachers' beliefs, knowledge, teaching practises as well as their ability to implement curriculum reforms can be transformed using teachers' professional development (Darling-Hammond, 2006; Desimone, 2009). For example, Desimone (2009) concluded that when teachers' professional development is well planned it "alters teacher knowledge, beliefs, or practice and the theory of instruction (e.g., that changed practice influences student achievement)" (p. 185). Thus, professional development is an "essential ingredient for creating learner-centred schools" (Loucks-Horsley, 1995, p. 271) as it transforms teachers' classroom teaching practises. The next section of this literature review discusses the potential of professional development and professional learning communities (PLCs) of teachers as a strategy for enhancing teachers' professional skills and knowledge.

2.7 Professional development as a strategy for acquiring new teaching skills

There are many terms that are used interchangeably to mean teachers' professional development, which include 'staff development', 'in-service education', 'staff training', and 'professional learning' (Ferrier-Kerr, Keown, & Hume, 2008; Loucks-Horsley, Stiles, & Hewson, 1996; Schwartz & Bryan, 1998). While there are also various definitions of teachers' professional development, Darling-Hammond and McLaughlin (1996) concisely defined it as "deepening teachers' understanding about the teaching/learning process and the students they teach," which they argue "must begin with pre-service education and continue throughout a teacher's career." (p. 203). For the purpose of the present study, professional development is defined as opportunities offered to teachers to develop knowledge, skills, approaches and dispositions to improve their effectiveness in their classrooms teaching (Hedberg, 2008).

A number of studies have reported that educational administrators have been using teachers' professional development programmes for different purposes such as certification of unqualified teachers, preparation of teachers for new roles, dissemination of new curriculum materials or refresher courses for new curricular (Dall'Alba & Sandberg, 2006; Lawless & Pellegrino, 2007; Villegas-Reimers, 2003). Teachers who participated in such professional development are reported to have acquired new teaching skills and changed their beliefs about student learning (Desimone, 2009; Nelson, 1998; Speck & Knipe, 2005). In work by Komba and Nkumbi (2008), teachers perceive that participation in professional development improved their professional growth, academic ability and technological literacy. Despite the agreed potential of teachers' professional development in helping teachers acquire new teaching skills and grow professionally, some professional development activities are negatively perceived and criticised by educational researchers (Borko, 2004; Ferrier-Kerr et al., 2008; Lieberman, 1995). Because of the nature of traditional professional development activities, such as attending 'one-shot' workshops, conferences, and seminars, it is claimed they fall short in helping teachers acquire new skills (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Kwakman, 2003; Lieberman, 1995). Borko (2004) observed that the professional development programmes available and conducted in schools are "woefully inadequate, fragmented, intellectually superficial, and do not consider how teachers learn" (p. 4). The way in which some forms of professional development are organized and conducted does not help teachers learn how to teach for understanding, because teachers are themselves treated as passive learners (Corcoran, 1995; Guskey, 2002; Kwakman, 2003; Richardson, 2003; Vescio, Ross, & Adams, 2008). In addition, many professional development planners assume that teachers need outside assistance (expert knowledge), knowledge being transmitted from professional development expert to teachers (Timperley, 2008). The traditional teachers' professional development practices of 'one-shot workshops' are contrary to the notion of the constructivist theory of learning and undermine the belief that teachers are active learners and knowledge constructors.

As a result of the ineffectiveness of some professional development programmes in achieving the purpose of involving teachers' in active learning, teachers' professional development recently took a new approach called 'professional learning' (Darling-Hammond et al., 2009; Ferrier-Kerr et al., 2008; Hord, 1997; Lieberman, 2000). This new outlook provides more active learning opportunities for teachers (Hord, 1997). 'Professional learning' is considered an internal process through which individuals acquire professional knowledge and skills and change their attitude to improve student learning (Timperley, Wilson, Barrar, & Fung, 2008). It is conceptualised "as a product of both externally-provided and job-embedded activities that increase teachers' knowledge and change their instructional practice in ways that support student learning" (Darling-Hammond et al., 2009, p. 1). Timperley et al. (2008) argue that the two terms 'professional learning' and 'professional development' are intimately intertwined, and that "without professional learning, professional development is unlikely to have any impact, so any well-constructed professional development experience should be designed to promote [teacher] learning" (p. 3). Therefore, implementation of professional development training needs to change from the traditional approach of imparting new skills to teachers to improving teachers' abilities and learning of new skills for the purpose of enriching their pedagogical skills; and this extension of professional learning can be achieved through adopting the characteristics of effective professional development. Thus, the next section discusses the characteristics of effective professional development.

2.7.1 Characteristics of effective professional development

Teachers' classroom practises can be improved through effective teacher professional development (Borko, 2004; Darling-Hammond & Richardson, 2009; Guskey, 2002; Peterson, 2002; Richardson, 2003). There is a consensus in the literature on the characteristics that makes professional development effective (Desimone, 2009; Guskey, 2003; Loucks-Horsley et al., 1996). Most writers agree that effective professional development possess some of the following characteristics:

- driven by a clear and well-defined image of effective classroom learning and teaching (Desimone, 2009; Loucks-Horsley et al., 1996; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010);
- integrate instructional methods to promote learning for adults that mirror student learning (Loucks-Horsley et al., 1996);
- conducted for a sufficient time, at least a semester or minimum of 80 hours' instruction time (Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Supovitz & Turner, 2000);
- provide teachers with opportunities to develop content knowledge, pedagogical knowledge and PCK (Desimone, 2009; Guskey, 2003; Loucks-Horsley et al., 1996);
- prepare and support teachers to serve in leadership roles (Loucks-Horsley et al., 1996);
- build or strengthen the community of learning and promotion of collegiality and collaborative exchange among the participants (Darling-Hammond & McLaughlin, 2011; Garet et al., 2001; Guskey, 2003);
- school-based or conducted on site and engage teachers in concrete classroom practice of new teaching skills (Desimone, 2009; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Supovitz & Turner, 2000);
- continuous and consciously linked to other parts of the educational system reforms or school change (Darling-Hammond & McLaughlin, 2011; Desimone, 2009; Loucks-Horsley et al., 1996);
- give teachers the opportunity to evaluate professional their development activities (Garet et al., 2001; Guskey, 2003; Loucks-Horsley et al., 2010);
- offer teachers opportunities for active learning such as reviewing students work and obtaining feedback of their teaching (Garet et al., 2001; Rogers et al., 2007); and
- sustained, on-going, intensive and supported by practice such as coaching, modelling and collective problem solving (Darling-Hammond & McLaughlin, 2011; Rogers et al., 2007).

In summary, according to D. Fraser (2005) effective professional development:

> ...focuses on developing the core attributes of an effective teacher. It enhances teachers’ understanding of the content they teach and equips them with a range of strategies that enable their students to learn that content. It is directed towards providing teachers with the skills to teach and assess for deep understanding and to develop students’ metacognitive skill. (p. 4)

There is a paucity in the literature on the direct link between professional development and its impact on student achievement or learning (Frechtling, Sharp, Carey, & Vaden-Kiernan, 1995; Garet et al., 2001; Shymansky, Yore, & Anderson, 2004; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Frechtling et al. (1995) and Slavin (2003) reported that it is difficult to establish a direct linkage between professional development and student achievement because many factors intercede, such as the socio-economic status of schools and students, class size, parents’ background, students’ commitment to learning and culture of school management. Shymansky et al. (2004) commented that “these complexities make the design and execution of true experimental studies that can isolate and measure the specific effects of professional development on student achievement both difficult and expensive” (p. 772). Similarly, C. C. Johnson, Kahle, and Fargo (2007), reported that the “current research base failed to demonstrate a clear relationship between professional development and student performance” (p. 2). For example, Frechtling et al. (1995) and Garet et al. (2001) reported on studies evaluating the impact of professional development on student achievement and they concluded that these studies were in the early stages and that few studies provided only the preliminary direction about the characteristics of effective professional development programmes. Garet et al. (2001) argued that:

> …relatively little systematic research has been conducted on the effects of professional development on improvements in teaching or on student outcomes…. there is little direct evidence on the extent to which these characteristics relate to positive outcomes for teachers and students. (p. 917)

However, some recent studies have provided some empirical evidence on the impact of professional development on students’ achievement (Guskey, 2002; C. C. Johnson & Fargo, 2010; Ross, Hogaboam-Gray, & Bruce, 2006; Yoon et al., 2007). For example, Yoon et al. (2007) identified three stages in the impact of professional development on student achievement: first, professional development enhances teachers' teaching knowledge and skills; second, teachers' enhanced knowledge and skills in turn results in improved classroom teaching practices; and finally, the improved teaching practices raises students' general achievement. Ross et al. (2006), in documenting the impact of professional development on student achievement in mathematics, reported significant student achievement gains in mathematics for the treatment group while no increase was observed for the control group. In science C. C. Johnson et al. (2007) conducted a longitudinal quasi-experimental study over a three year period and reported significant gains in student achievement in years two and year three of the professional development intervention. They concluded that "teacher participation in effective, sustained, professional development and their subsequent use of standards-based instructional strategies have a positive impact on their students' performance in science" (p. 10). Likewise, in another longitudinal study, C. C. Johnson and Fargo (2010) reported that students in treatment schools had higher achievement gains in science than those students taught by teachers of control school, who had not participated in the professional development training.

Despite a consensus on the characteristics of effective professional development, little is known about how these characteristics work and how they can be applied in professional development programmes to have a positive impact on student achievement (Garet et al., 2001). Thus, there is a need for systematic research into how the specific characteristics make professional development work effectively and the relationship with student learning. Darling-Hammond (1997) recommended that effective professional development activities be entrenched in teachers' daily work, involving them in joint lesson planning, study groups, mentoring and peer coaching, and action research. Despite knowing these characteristics, a variety of professional development models are still being used. These models of professional development are discussed in detail in the next section.

2.7.2 Models of teacher professional development

Various studies have identified different professional development models that are commonly used in teacher education (Corcoran, 1995; Guskey, 2000; Holmes Group, 1990; Kriek & Grayson, 2009; Kuijpers, Houtveen, & Wubbels, 2010; Sparks & Loucks-Horsley, 1989; Westchester Institute for Human Services Research, 2007). However, most of the literature on teacher professional development models is built on the work of Sparks and Loucks-Horsley (1989) and the Westchester Institute for Human Services Research (2007), who identified six different professional development models. These models are described in detail below, including the assumptions underpinning each model, and the strengths and weaknesses of each model.

The Teacher Network Model. This approach provides teachers with a supportive professional learning community (PLC) beyond the school and involves teachers' work groups. The approach is typically organized around specific subject-matter, and seeks to deepen teachers' understanding of content as well as new teaching strategies (Darling-Hammond & McLaughlin, 2011; Sullivan, 1999). Some of these networks are national in scope, while others cover only one state or region and members stay in touch via electronic bulletin boards (Corcoran, 1995; Villegas-Reimers, 2003; Westchester Institute for Human Services Research, 2007; Wood, 1997). In this model teachers share responsibility for different tasks, such as team teaching, curriculum writing, assessment development, and other activities that create interdependence and cooperation among teachers. This teacher network model promotes on-the-job learning because it facilitates productive exchanges of knowledge among teachers and the sharing of reflections on their teaching practices (Westchester Institute for Human Services Research, 2007). Villegas-Reimers (2003) reported that "the main goal of this network was to implement some actions on the research sites and also to contribute by generating some knowledge about the practice of teaching" (p. 109). The major assumptions guiding this model according to Villegas-Reimers (2003) include: first, teachers address the problems which they experience in their daily work as individuals and as groups; second, teachers manage their own networks and share the experience with experts. The major strengths of this model: first, it is flexible because it allows the use of online networking; second, teachers' learning is personalized and involves both formal and informal learning because it is not bound by institutional schedules (Lieberman, 2000). The major weakness of the teacher network professional model, according to Villegas-Reimers (2003), is that they typically receive little or no funding from government.

The Improvement Process Model. This model involves collaboration between schools and teacher education colleges or universities, where schools are used as 'laboratories' for prototyping innovations. In this model teachers participate in designing programmes and they engage in systematic school improvements where participation is focused on improving classroom instruction or the curriculum (Sparks & Loucks-Horsley, 1989). Organizations such as the Carnegie Corporation and the Pew Charitable Trusts in the United States actively promote such partnerships between colleges and K-12 schools (Holmes Group, 1990; Westchester Institute for Human Services Research, 2007). These cooperative programmes seek to help teachers gain access to new knowledge; and they enable university researchers to develop new understanding on how to teach their pre-service teachers (Guskey, 2000). The improvement process model uses professional development schools like 'teaching hospitals' in which to experiment and 'treat' weaknesses in both subject content and teacher pedagogy. The major assumptions of this model according to Sparks and Loucks-Horsley (1989) include: first, teachers are adults and adults learn more effectively when they need to know or to solve the problem affecting their practice; second, people working closest to the job best understand what is required to improve their performance and how to change their practice; and third, teachers acquire important knowledge or skills through their involvement in school improvement or curriculum development processes. The major strengths of this model are that it creates opportunity for teachers to interact with experts from outside the school environment and share their experiences and knowledge, and teachers learn formal research skills from university experts (Guskey, 2000; Lalitha, 2005). However, the major weakness of this model is that it is restricted to a small portion of teachers because it involves only a few schools in partnership with a university or college (Guskey, 2000).

The Action Research Model. In this model teachers use basic classroom research techniques, formulate research questions around identified teaching and learning issues/problems in their classroom practice, gather and analyse the data, and use the results for improving classroom techniques (Sparks & Loucks-Horsley, 1989). The action research model is used for replacing traditional teaching methods, improving teaching skills and developing new teaching methods (Cohen, Manion, & Morrison, 2007). This model may involve small groups, study groups and even the entire school as a unit of investigation. The major assumptions in this model, according to Loucks-Horsley et al. (1987) are that teachers are intelligent, inquiring individuals with legitimate expertise and have rich experience to improve their practises. Such teachers are inclined to search for data to answer pressing questions and to reflect on the data to formulate solutions. They will go on to develop new understanding as they formulate their own questions and collect their own data to answer them. The strengths of this model include: first, helps teachers and educators to be more reflective problem-solvers; second, helps teachers to improve their classroom practice (Guskey, 2000). Guskey (2000) observed that this model requires a high level of individual commitment of time and success depends on the time taken for the inquiry process, which is the major weakness of this model.

The Individually Guided Model. In this model, teacher educators and teachers determine professional development learning goals and select different activities to achieve them (Guskey, 2000). The major assumptions inherent in this model are that individual teachers can judge their own learning needs; they are capable of self-direction and self-initiated learning, and more motivated to learn when they initiate their own professional development programme (Guskey, 2000; Sparks & Loucks-Horsley, 1989). Sparks and Loucks-Horsley (1989) proposed four phases of an individually guided model that can be followed formally or informally. These phases are: first, the identification of a need or interest; second, the development of a plan to meet the need or interest; third, designing the learning activity(ies); and fourth, assessing whether the learning meets the identified need or interest (Sparks & Loucks-Horsley, 1989). The strengths of this model are that it is flexible because it depends on individual choice, it provides an opportunity for self-evaluation and personal reflection, and it guides individual decision making (Guskey, 2000). However, there are few opportunities for sharing skills and knowledge because the notion of collaboration does not exist for individually guided professional development.

The Observation Model. This model uses the power of feedback from collegial observations, featuring the strategies of peer coaching, mentoring and clinical supervision. The model allows the sharing of experiences among teachers, with a highly experienced teacher playing the leadership role in guiding the activities of the other teachers. For example, mentoring programmes often match beginning teachers with veterans, enabling the veterans to share their knowledge and expertise (Hennissen, Crasborn, Brouwer, Korthagen, & Bergen, 2011; Hobson, Ashby, Malderez, & Tomlinson, 2009; Leslie, 2001). Guskey (2000) commented that "one of the best ways to learn is by observing others, or being observed and receiving feedback from that observation" (p. 23). The four assumptions guiding the observation model include: first, classroom observation and assessment can provide the teacher with data to reflect upon and analyse to help improve instruction and, ultimately, student learning; second, that reflection by an individual on his or her own practice can be enhanced by another person's observations; third, observation and assessment of classroom teaching can benefit both parties involved - the teacher being observed and the observer; and the last assumption is that when teachers see positive results from their efforts to change, they are more apt to continue to make improvements (Sparks & Loucks-Horsley, 1989). The major strength of this model is that it benefits both the observer and the observed, while the main challenge is that the assessment/observation model requires commitment and significant time from both the observed and the observer (Guskey, 2000).

The Training Model. This model uses a workshop approach, with teachers attending workshops where the presenter of the workshop is the expert, who designs the content and all other activities in the whole session (Guskey, 2000; Sparks & Loucks-Horsley, 1989). Lalitha (2005) reported that the workshops are conducted with a clear set of learning objectives and learner outcomes. Outcomes are usually described as the knowledge and skills that the learners will demonstrate after the training sessions. The training model has two major assumptions: first, there are worthy new behaviours and techniques that teachers need to acquire for classroom practice; second, that teachers can change their behaviours and learn to replicate behaviours in their classroom that were not previously in their repertoire (Sparks & Loucks-Horsley, 1989). The study by Sparks and Loucks-Horsley (1989) identified the following strengths of training models: first, it is a cost-effective means by which teachers acquire knowledge and skills; and second, it can help to teach many participants in a short time. On the other hand, Villegas-Reimers (2003) critiqued this model and claimed that first, 'one-shot' workshops do not address the long-term developmental nature of learning; second, the model lacks sufficient follow-up support for teachers to successfully implement the new practice; and third, sometimes evaluation is difficult because training is usually conducted in a very short time and training materials are not relevant to the needs of the teachers and the school context.

Despite the existence of different models of teachers' professional development much professional development activity fails to achieve the intended purpose of helping teachers' professional growth (Borko, 2004; Guskey, 2000; Guskey & Yoon, 2009; Lieberman, 1995). Many models are introduced in schools without sufficient analysis of either external or internal factors, such as an assessment of teachers' learning needs, availability of resources and the involvement of teachers in planning professional development activities (Bantwini, 2004; Guskey, 2000, 2002). Professional development implementers frequently use a top-down approach that considers teachers the receivers of knowledge (Bantwini, 2004), and often they neglect to address the pertinent issues of if and how student are learning better because of professional development (Guskey, 2000).

In summary, the literature indicates that no single model for professional development is able to address teachers' learning needs (Guskey, 2000, 2002; Kuijpers et al., 2010; Sparks & Loucks-Horsley, 1989); because each professional development model makes different assumptions. Guskey (2000) concluded that "it is unlikely that any single model will prove effective for all individuals under all conditions. The appropriateness of any particular model varies depending on the goals, the content, and the context for the implementation" (p. 29). This finding suggests that if professional development is to have positive impacts on teachers' and students' learning it should integrate different professional models depending on the context of the learners.

2.7.3 Professional learning communities (PLCs) as a new approach for teachers' professional development support

For more than two decades, there has been a paradigm shift in many developed countries with regard to teacher professional development, moving beyond mere support for the acquisition of teaching skills by teachers to knowledge creation through the development of 'professional learning communities' (Vescio et al., 2008; Webster-Wright, 2009). According to DuFour and DuFour (2006) a 'professional learning community' (PLC) "is a group of educators committed to working collaboratively in on-going collective inquiry and action research in order to achieve better results for the students they serve" (p. 3). PLCs encompass a collaborative model of working relationships between school leaders and teachers as professionals (Mizell, 2009). As Ferrier-Kerr et al. (2008) asserted the "emphasis is now turning to collaborative models for professional development and learning, and attention in schools has switched to professional learning communities as the means by which meaningful, long-term change can be achieved" (p. 125).

Vescio et al. (2008) outlined two basic assumptions to guide the learning process in PLCs. First, it is assumed that knowledge is found in the daily experiences of the teacher, and is well understood through critical reflection with other teachers, especially those who share the same teaching experience. Second, actively engaging teachers in a PLC will help to increase their professional knowledge and improve student learning outcomes. Several research studies have identified the inherent characteristics that make professional learning successful for promoting teacher change and positive student learning outcomes. The characteristics of PLCs commonly reported in the literature include:

- values and vision that are shared by members of the PLC (DuFour & DuFour, 2006; Ferrier-Kerr et al., 2008; Kruse, Louis, & Bryk, 1994);
- collective responsibility, whereby teachers are mutually accountable in relation to changing classroom practices, with the main focus being on

improving students' learning (DuFour, 2004; D. Fraser, 2005; Kwakman, 2003; Vescio et al., 2008);

- collaboration among members of the PLC that promotes changes in the teaching culture by participating openly in discussions to encourage sharing of knowledge (Cormier & Olivier, 2009; Feger & Arruda, 2008; Ferrier-Kerr et al., 2008);
- the presence of reflective dialogue among members of the PLC on teaching and learning issues: such as curriculum development, planning and the applications of innovations in teaching (Ferrier-Kerr et al., 2008; Hord, 1997);
- de-privatizing the practice of teaching by teachers through the sharing of personal classroom practice and experiences with others teachers in the PLC (Cormier & Olivier, 2009; Kruse et al., 1994; Vescio et al., 2008); and
- supportive environment as the school leadership shares responsibilities within the community of practice (DuFour, 2004; Feger & Arruda, 2008; Kwakman, 2003).

Research shows that professional development aligned to these characteristics of PLCs significantly changed teachers' classrooms practices and student learning (Hord, 1997; Supovitz & Christman, 2003). Teachers were reported to have a positive perception of work efficacy, work satisfaction, and collective responsibility for student learning because of their engagement in PLCs (Bissaker, 2009; Kruse et al., 1994). Darling-Hammond et al. (2009) reported that PLCs "help teachers continuously improve by better understanding students' learning needs, making data-driven decisions regarding content and pedagogy, and assessing students' learning within a framework of high expectations" (p. 3). Of particular note is the observation by Phillips (2003) that students taught by teachers in schools with PLC programmes have significantly higher scores in science than students in the schools without PLC programmes.

PLCs, despite their popularity, have their critics (Servage, 2009; Tarnoczi, 2006). For example, (Tarnoczi, 2006) criticized the foundational assumptions entrenched in the concept of PLCs. He outlined three weaknesses: first, they limit teachers' learning and support the status quo because of the normalization of individual differences; second, they shift the responsibility for educational problems onto the shoulders of individual teachers; and finally, the design of PLCs allows the authorities or school management to easily manipulate teachers to pursue their administrative agenda, which may be unrelated to classroom teaching. Servage (2009) also reported that what is learned in some PLCs varies and is not determined by the teachers themselves. The next section discusses the alternative route to teacher recruitment as a strategy for addressing teacher shortage.

2.8 Alternative route teacher recruitment as a pathway for addressing the shortage of teachers

The alternative route to teacher recruitment or non-traditional university teacher recruitment and licensing them to teach has been in use in education for almost four decades to increase the number of teachers in schools. However, the literature lacks a common nomenclature (Husbands, 2008; Zeichner & Schulte, 2001) and various names are used in the literature to refer to these forms of non-traditional university-based teacher recruitment and licensure including: alternative certification, alternative routes to certification, alternative teacher education, non-traditional teacher preparation, alternate routes to teaching, licensed teachers, crash programme teachers, and others (Barclay et al., 2007; Cohen-Vogel & Smith, 2007; Dahlkemper, 2001; 2008; Shen, 1997). Despite the many labels for non-traditional university-based teacher recruitment, the literature is generally agreed on a meaning for these variants. Barclay et al. (2007) for example, say that the alternative route to teacher recruitment refers "to creations by state licensing agencies that are alternatives to the traditional college, campus-based undergraduate teacher education programme route culminating in a certificate (license) to teach" (p. 8).

Candidates recruited through alternative routes are heterogeneous in terms of educational background (Humphrey et al., 2008; Walsh & Jacobs, 2007), some have bachelor degrees, or postgraduate qualifications, while others in developing countries come with just a basic secondary school qualification (Shaban, 2007; Sydney, 2008). Studies report that the educational background and qualification of alternative route candidates vary from one country to another depending on the demand and the available pool of applicants (Barclay et al., 2007; Dahlkemper, 2001; Pandey, 2009). For example, countries such as the United States, England, and Finland, recruit non-education bachelor degree holders, postgraduate diplomas and master's graduates to join the licensed teacher certification programmes, and these teacher trainees typically have good subject content knowledge, but lack pedagogical knowledge (Legler, 2002; Ng, 2003). Other studies report that some alternative routes to teacher recruitment programmes are non-selective, they accept all applicants regardless of their academic background and qualifications (Dahlkemper, 2001; Walsh & Jacobs, 2007).

Not only is there variation in the qualification and backgrounds of candidates for alternative route recruitment programmes, there is also extreme variation in the nature of alternative route teacher programmes (Glazerman, Mayer, & Decker, 2006; Shaw, 2008), including differences in the: size of the programme, background knowledge of the applicants, mode of administering the programmes, content of the programme, and duration of training (Birkeland & Peske, 2004; Glazerman et al., 2006). Despite these variations, Dahlkemper (2001) was able to identify what he believed were common elements of an effective alternative teacher certification programme. These included:

- rigorous screening: candidates must demonstrate mastery of content, undergo an interview, and pass a test;
- strong mentoring: mentors are well-trained and work regularly with teaching interns;
- field-based experience: prospective teachers receive hands-on training in the classroom before they are expected to teach on their own;
- location, location, location: programmes not only target geographic areas where the demand for teachers is the greatest but they are also located in those areas;
- tailor-made: programmes are designed for people who have a bachelor's degree and are keenly interested in pursuing a teaching career; and
- collaboration among partners: districts, local universities, state departments of education, and others work closely to ensure seamless, high-quality programmes. (Dahlkemper, 2001, p. 9)

Other education authors say that the alternative routes to teacher recruitment aligned to the features listed above positively help teachers to acquire the needed skills for classroom teaching (Feistritzer, 2002; Rosenberg & Sindelar, 2005). In contrast, others caution that "the research is inconclusive as to whether these characteristics, in fact, do contribute to better teaching among alternative route graduates" (Education Commission of the United States, 2003, p. 4). The research appears inconclusive because of an unresolved debate between the opponents and proponents of the alternative route to teacher recruitment (Education Commission of the United States, 2003). Proponents argue fervently that the alternative route to teacher recruitment:

- is less expensive and allows teachers to move directly into the classroom within a shorter time than the traditional university/college-based teacher recruitment approaches (Humphrey et al., 2008; Lynd, 2005; Shaw, 2008);
- is more attractive to the public who have lost trust in the traditional college-based training programmes as many of these graduates are unable to teach effectively in the classroom (J. W. Fraser, 2001; Haberman, 2004a);
- attracts skilled and talented personnel from other career backgrounds to the teaching profession who do not want the rigorous procedure of traditional college-based teacher recruitment (Barclay et al., 2007; Humphrey et al., 2008);
- helps as a short-term policy response for alleviating teachers' shortage in rural areas as many candidates for these programmes are willing to work in rural areas where college-based teachers are not willing to teach (Owings et al., 2006; Shaw, 2008; United States Department of Education, 2004);
- produces teachers who are equally effective as traditional university-based teachers (Barclay et al., 2007; Dahlkemper, 2001; Feistritzer, 2002; Goldhaber & Brewer, 2000); and
- provides teachers who are willing to teach in high-poverty schools, to teach high-demand subjects (such as special education, maths, science),

> who plan to remain in teaching, and who increase the teaching pool's diversity (Owings et al., 2006, p. 102).

On the other hand, opponents of the alternative route to teacher recruitment argue that studies supporting such recruitment have many methodological flaws and are purposely biased to fit the interests of the researchers and those who conduct the alternative route programmes (Seftor & Mayer, 2003; Walsh, 2001). The methodological flaws reported include relatively small and biased samples and variables for teacher effectiveness that were not well identified (Darling-Hammond & Youngs, 2002; National Centre for Alternative Certification, 2006; Walsh, 2001). For example, Walsh (2001, p. iv) reported that "research that is seen as helping the case for certification is cited selectively, while research that does not is overlooked". Opponents against the alternative route to teacher recruitment approach programmes argue that they:

- provide insufficient training and support to their candidates (Walsh & Jacobs, 2007);
- are non-selective in some cases allowing incompetent candidates to enter the classrooms (Mitchell & Romero, 2010; Walsh & Jacobs, 2007);
- are an ill-advised 'Band-Aid' for the teacher shortage problem (Mitchell & Romero, 2010, p. 365);
- water-down teacher preparation and the teaching profession by placing under-qualified and ill-prepared teachers in our classrooms (Darling-Hammond et al., 2001; Legler, 2002);
- produce teachers who are pedagogically weak, and some are even unable to learn content knowledge on their own (Cohen-Vogel & Smith, 2007; Education Commission of the United States, 2003);
- allow completely unqualified people to assume total responsibility for the classroom teaching (Cohen-Vogel & Smith, 2007; Darling-Hammond, 2000b); and
- fail to attract candidates to teach in schools that are difficult to staff and are therefore not a means of solving problem of teacher shortage (Cohen-Vogel & Smith, 2007).

While the debate over what constitutes the alternative route in teaching is yet to be resolved (Foote, Brantlinger, Haydar, Smith, & Gonzalez, 2011; Humphrey & Wechsler, 2007; Kee, 2011; Mitchell & Romero, 2010) with many studies providing mixed results (Darling-Hammond et al., 2001; L. S. Kaplan & Owings, 2002; Owings et al., 2006), what has emerged from this debate is a number of comparison studies on the effectiveness of alternative route teachers and traditional university-based trained teachers in classroom teaching (Glazerman et al., 2006; Kee, 2011; Owings et al., 2006). However, the results are inconclusive. For example, Owings et al. (2006) reported that alternative route teachers are "more effective in classroom instruction and classroom management/student discipline—and have a more positive impact on student achievement—than traditionally prepared teachers" (p. 102). Goldhaber and Brewer (2000) reported similar views that teachers with alternative certificates do better in the classroom than teachers with standard credentials obtained from traditional teacher education training. Other became embroiled in controversy over the clear meaning of alternative route to teacher recruitment (Darling-Hammond, 1990; Zeichner & Schulte, 2001). Darling-Hammond (1990) commented that the term:

> ...leaves a great deal of room for varied meaning. It can mean alternative ways to meet teacher certification requirements-such as a graduate level master's degree program rather than an undergraduate teacher education program. It can mean alternative standards for certification, which allow for truncated or reduced training-or for training completed during the course of a teaching career rather than prior to its initiation. Or it can mean alternatives to state certification itself, as when a state allows local employers to train and certify their own candidates. (p. 129)

Zeichner and Schulte (2001) hint that alternative route is lowering of professional standards.

> The controversy comes from the challenge posed by some alternative programs run by states and school districts to university and college control over pre-service teacher education. In some cases where the standards are lower than in college and university teacher preparation, alternative

> programs are viewed as undermining attempts to professionalize teaching because they minimize the need for specialized professional knowledge and imply that all a teacher needs is content knowledge and an apprenticeship in a school during an internship. (p. 266)

Despite the inconsistencies in research findings in this area of alternative routes to teacher recruitment, it is of concern that many studies have uncovered problems with alternative route training programmes. Darling-Hammond et al. (2002), for example, conducted a survey study to examine the preparedness of alternative route and traditional teachers in New York City. They reported that alternative route teachers are less prepared to help students in active learning, have less ability to promote classroom motivation and have inadequate skills for supporting students' higher order thinking. Alternative route teachers "feel somewhat less well prepared than traditionally certified teachers" (Kee, 2011, p. 23), and they are pedagogically ill-equipped (Cohen-Vogel & Smith, 2007). Still others reported that alternatively recruited teachers have inadequate content knowledge when teaching subjects like mathematics compared with teachers trained through a university-based approach (Zeichner & Schulte, 2001), and report more student behavioural problems in the classroom than traditionally trained teachers (Glazerman et al., 2006). In the study commissioned by 'The Abell Foundation' in the US, Walsh (2001) critically evaluated various studies relating to alternative route teacher recruitment and concluded that:

> Reduced to its essence, teacher certification [alternative route to teacher recruitment] is incapable of providing any insight into an individual's ability, intellectual curiosity, creativity, affinity for children, and instructional skills. So long as the deficiencies in the research on teacher quality are ignored, misrepresented, or debated, there are clear losers. They are the disadvantaged students who are most dependent upon the quality of their teachers and the opportunity provided by a high quality public school education. (p. 41)

Overall, the literature cited in this section on alternative routes to teacher recruitment is unconvincing and inconsistent in terms of the reported effectiveness of the alternative teacher recruitment approach. Yet, despite the inconclusive nature of the literature on the alternative teacher recruitment approach, it is gaining strength in many developing countries, in particular Sub-Sahara Africa, as a strategy for addressing the crisis of teacher shortage. Tanzania as one of these Sub-Sahara African countries that has adopted the alternative route to teacher recruitment as an attempt to address the shortage of teachers in secondary schools. However, little is reported in the literature on strategies for supporting currently deployed teachers recruited through the alternative approach in developing countries. The next section discusses various professional development initiatives conducted for science teachers in Tanzania to meet their professional learning needs.

2.9 Science teachers' professional development activities in Tanzania

In 1996, the Ministry of Education in Tanzania conducted a situational analysis to examine the state of the science curriculum and the teaching of science in secondary schools. The study reported that science teachers were professionally weak; the science education curriculum was dominated by subject content, classrooms focused on teacher-centred approaches, schools lacked textbooks and science teaching materials, and science teachers rarely conducted science practicals (Chonjo et al., 1996). As a result of this study, the MoEVT conducted a number of different intervention programmes using projects supported by donors such as the German and Dutch governments and the African Development Bank. These projects include the *Science Education in Secondary School* (SESS) programme, the *Science Teacher Improvement Project* (STIP), the *Education II Project*, and the *Teacher Education Assistance in Mathematics and Science* (TEAMS) project (O-saki, 2007). These projects are described in detail below.

The Science Education in Secondary School (SESS) project: This project was funded by the government of Tanzania and Germany and conducted in the three regions of Coast, Dodoma and Iringa in Tanzania mainland for the purpose of improving the status of science and mathematics teaching in ordinary (junior) level secondary schools. The project involved 28 secondary schools and one teacher per subject, per school. The in-service training programmes in the project were conducted using a ‘cascade design’ that trained the ‘trainer of trainers’ in workshops attended by one teacher from each of the 28 schools selected in the project. The project successfully supplied the science textbooks and laboratory equipment to the selected project schools; but there was very little change in teachers’ classroom practices (O-saki, 2007). The trainers of trainers were unable to transfer the skills and knowledge to their colleagues because they lacked facilitation skills, and the nature of the ‘one-shot’ workshop approach was inadequate for transferring skills to trainers of trainers.

The *Science Teacher Improvement project (STIP)*: This German-funded project was similar to the SESS programme, and was intended to improve science and mathematics teaching in schools owned by a Christian social service organization in Tanzania. Science and mathematics textbooks were supplied to church schools and science teachers were provided with in-service training. The project conducted teachers’ professional development workshops to enhance science and mathematics teachers’ PCK (Kitta, 2004). The workshops used a ‘Starter Experiment Approach’ philosophy where the teaching of any science topic starts with experiments first followed by students’ discussion (Kitta, 2004). The project ended in 2003, but no evaluation was conducted to study the impact of the STIP in promoting science and mathematics teaching in the church-owned secondary schools (O-saki, 2008).

The Teacher Education Assistance in Mathematics and Science (TEAMS) project: This project started in 1995 and was funded by the Dutch and Tanzanian Government. The project was conducted as a collaboration between the University of Dar Es Salaam and three Dutch institutions of higher learning (O-saki, 2007). As part of the implementation process the project: reviewed science education courses at the University of Dar Es Salaam; introduced five new teacher education undergraduate programmes; one postgraduate programme in science and mathematics education was introduced; trained four university staff to PhD level in education in Dutch universities and produced a number of Master of Education science graduates. The trained PhD graduates were required to teach pedagogical courses for science and mathematics teacher education classes, while the Masters of Education Science graduates were to teach science in secondary schools and teaching method courses in teacher training colleges in Tanzania.

Donor support for this project ended in 2005; however, the training for the undergraduate and master's degree in science education is still in place at the University of Dar es Salaam. This project is an example of a donor-funded capacity building project that was well planned and sustained after the end of donor support. However, many of the teachers trained in Masters of Science Education are not reporting back to their previous teaching positions, and are not teaching in the classroom, which remains an unanswered challenge. Many of these teachers, after graduation, search for greener pastures because the teaching profession is poorly paid in Tanzania.

The Education II Project: This project was funded by a loan from the African Development Bank (ADB) and had four main objectives. These objectives are first, to improve Technical and Secondary Education on Tanzanian mainland; second, to strengthen science teaching in 306 government and 36 community-built public schools on the mainland by providing teaching materials and in-service training for science and mathematics teachers; third, to provide alternative education for out-of-school children and adult literacy in non-formal education settings with a strong focus on girls and women on Tanzania mainland; and fourth, to improve the quality of education in primary schools in Zanzibar (African Development Bank, 2007). The ADB final evaluation report shows some positive quantitative successes for the project's intended goals. For instance, 120 teachers received in-service training in technical secondary schools; three fully furnished laboratory rooms, one special practical room, and four ancillary rooms were provided at each of the 36 community-built public secondary schools; 400,000 textbooks (mathematics, physics, chemistry and biology) were supplied to 306 secondary schools and 900 science and mathematics teachers received in-service training in teaching methods (African Development Bank, 2007). The Education II Project developed in-service training modules for science and mathematics teachers and these are now in use for in-service training workshops at community secondary schools (O-saki, 2007, 2008).

The success of the Education II Project and the impact of the in-service professional development materials developed for enhancing science and teachers' mathematical pedagogical knowledge skills in community secondary schools are not yet known. O-saki (2008) reported that, no evaluation has been carried out to determine the impact on student learning.

2.10 The need for professional development support for Tanzanian teachers

Despite these Government and donor effort (as discussed in section 2.9) to improve teachers' professional skills in Tanzania, studies by Komba and Nkumbi (2008) and Okuni (2007) reported that teacher professional development in Tanzania is inadequately supported and poorly coordinated at all levels (national, regional, district, ward and school level) and sometimes it is insufficiently funded. The lack of professional development support in Tanzanian secondary schools was also reported by the Ministry of Education and Culture:

> ...many teachers return to schools to find little professional support for implementing the newly gained skills or even receiving coaching and feedback on their professional practice. There is need, therefore, to develop a ward based professional support programme.... if trials are to successful expand to ward-based professional development initiative to all districts. (Ministry of Education and Culture, 2001, p. 36)

This quote suggests that all Tanzanian teachers, regardless of training, need professional learning support to enhance their teaching skills as many teachers receive little in-service support to enhance their teaching skills. This study set out to implement PDI specifically to enhance licensed science teachers' PCK needs since they appear to have heightened PCK development needs. The PDI adopted features of PLCs, as Timperley et al. (2008) claimed that if a PDI is to be effective, it should be integrated into core characteristics (see section 2.7.3) of PLCs. The professional learning approach is considered suitable for the Tanzania situation because it provide collaborative opportunities for licensed teachers to collaborate with more expert members of staff in the same field, sharing skills, knowledge and collective reflections on student learning outcomes.

This study adopted two models of teachers' professional development: the *individually guided* professional development model and *teacher network* professional development model for the design of the PDI. The researcher judged these two models to be most appropriate for this study from the range of professional development models available (refer to Section 2.7.2 for detailed assumptions for teachers professional development models). The choice of these models was guided by the intended purpose and goals of the PDI to be used in this study. This study first involved licensed science teachers in the identification of their professional learning needs through individuals interviews, focus group discussion, and classrooms observations. Second, the licensed science teachers and the researcher developed a PDI programme to meet some of the teachers' identified learning needs. Third, teachers from four different secondary schools participated in workshop learning activities in order to enhance their professional learning and develop teacher networking groups. Finally, an evaluation of the intervention programme was conducted by the researcher and teachers to see whether or not the intervention had impacted the teachers' teaching skills. These steps in the study design concur with the phases in the *individually guided* professional development model. The individually guided professional development model requires teachers to: identify their professional learning needs; develop a plan of action to meet the identified needs; conduct training activities; and evaluate the impact of the training or programme (Guskey, 2000; Hien, 2009; Sparks & Loucks-Horsley, 1989). The individually guided professional development model assures teachers of what to learn, how to learn and why they need to learn (Hien, 2009); it also provides participants with flexibility and opportunities to make a choice about activities because it needs driven and allows self-evaluation and personal reflection (Guskey, 2000). Sparks and Loucks-Horsley (1989) argued that "programs with individualized activities were more likely to achieve their objectives than were those that provided identical experiences for all participants" (p. 42). According to Hien (2009) the individually guided professional development model "does not mean that teachers themselves learn and obtain development without any help from other people and resources; it indicates that the learning of teacher-students is actually self-directed adult learning" (p. 5), allowing teachers to make contact with books and learning resources, and discuss issues with their colleagues and other professional experts.

The *teacher network* professional development model complements the *individually guided* professional development model because "teachers' networks bring teachers together to address the problems which they experience in their work, and thus promote their own professional development as individuals and as groups" (Villegas-Reimers, 2003, p. 80). Teachers' networking is also reported as a key factor in their learning (Avalos, 2011), and networks are used by teachers as a means of communication to discuss their professional development issues, and to critique their own work (Sullivan, 1999; Villegas-Reimers, 2003). Significantly, the *teacher network* professional development model helps the formation of strong 'communities of practice' of teachers (Lieberman, 1995; Villegas-Reimers, 2003; Wenger, 2006). The 'communities of practice' teachers are defined as "groups of people [teachers] who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2006, p. 2). Such teacher "networks, collaborations, and partner-ships provide teachers with professional learning communities that support changed teaching practices in their own schools and classrooms" (Lieberman, 1995, p. 75) Communities of practice are used as centres for improving teaching, conducting reflection groups, mapping knowledge and identifying gaps, problem solving and sharing expertise with others from different schools in ways that are important for classroom teaching and likely to improve student learning achievement (Cuddapah & Clayton, 2011; Lieberman, 2000; Villegas-Reimers, 2003).

2.11 Summary of the chapter

The literature reviewed in this study indicated that there is considerable debate between the proponents and opponents of alternative route teacher recruitment approaches about the quality and effectiveness of teachers recruited via the alternative route approach in enhancing student learning. Proponents argued that teachers recruited through the alternative route approach are equally effective, and are similar in quality to those trained through the traditional university-based approach. In contrast, opponents argued that teachers recruited through the alternative route are pedagogically weak, poorly qualified, and unable to teach students so that they attain higher level of cognitive skills. They added that allowing these teachers to teach in our schools is 'watering down' the quality of education. The literature strongly supports the notion that 'teacher quality matters', in fact, the evidence is that teacher quality is the most important variable in terms of enhancing student academic achievement. Students taught by qualified teachers are reported to have higher success in examinations than those taught by under-qualified teachers including licensed teachers. The literature review also reported that teachers' participation in effective professional development training and professional learning helps the novice as well as qualified and unqualified teachers to acquire skills and meet their PCK needs. The literature also examined the characteristics that make teachers' professional development and PLCs effective. Also, it was reported in the literature that there is no single comprehensive professional development model for addressing teachers' professional learning needs, but an effective PDI combines various models to meet teachers' professional learning needs.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology used in this study. Research methodology "is the overall strategy that is used to seek new knowledge that can be considered trustworthy" (Horn, 2002, p. 160). It comprises the steps adopted by the researcher to investigate research problem and the reasons for choosing those steps (Kothari, 2009; Sikes, 2004). Research as an inquiry to acquire new knowledge is guided by a set of philosophical beliefs, assumptions, and systematic methodological processes (Avramidis & Smith, 1999; Cohen et al., 2007; Creswell, 2009; B. Johnson & Onwuegbuzie, 2004). The set of philosophical beliefs that guide researchers and research processes is referred to as a research paradigm (Cohen et al., 2007; Creswell, 2009; Guba & Lincoln, 1994). This chapter presents the research paradigm underpinning this study and justifies the choice. It also outlines the research approach and design, data collection techniques, sampling methods, data analysis procedures and ethical issues considered in this study.

3.2 Research paradigm

The concept of paradigm was first popularized by Thomas Kuhn in his famous book 'The Structure of Scientific Revolutions' (Avramidis & Smith, 1999; Kuhn, 1970; Maxwell, 2008; Wray, 2011). A paradigm is defined as a "basic set of beliefs that guide action" (Guba, 1990, p. 17). According to Maxwell (2008) paradigm "refers to a set of very general philosophical assumptions about the nature of the world (ontology) and how we can understand it (epistemology), assumptions that tend to be shared by researchers working in a specific field or tradition" (p. 224). These philosophical assumptions guide the researcher by providing clear perspective of: the nature of reality (ontology); the nature of knowledge or how a researcher knows what s/he knows (epistemology); the best way of gaining knowledge about world (methodology); the values that guide the research (axiology); and appropriate use of language for the research or how the art of language is applied in writing up the research (rhetorical) (Bryman, 2008; Creswell, 2009; Firestone, 1987; Guba & Lincoln, 1994; Sarantakos, 2005). According to Creswell (2009) these philosophical assumptions are important tenets underpinning the researcher's choice of research approach. Paradigms, as a set of philosophical assumptions, are socially constructed and continuously emerging as new complexities of knowledge arise in research. The next section discusses in detail the types of social science research paradigms commonly used in educational research.

3.2.1 Types of research paradigms

Literature on the classification of research paradigms is inconsistent and many writers on research methodology are influenced by their discipline of specialization such as sociology, psychology and natural science in classifying types of research paradigms. This inconsistency in the literature suggests that there is a plethora of categories of paradigms that are used in research. Writers like Avramidis and Smith (1999), Dash (2005) and Guba and Lincoln (1994) identify four major research paradigms in social science research. These are: positivism, postpositivism, interpretivism/constructivism and critical theory. However, Blaikie (2010) groups paradigms into two major categories: the classical research paradigms and the contemporary research paradigms. Classical research paradigms include: positivism, critical rationalism, classical hermeneutics and interpretivism; while contemporary research paradigms include: critical theory, ethnomethodology, social realism, contemporary hermeneutics, structuration theory and feminism. Creswell (2009) and Patton (2002) suggested four types of worldviews (paradigms): postpositivism, constructivism, advocacy/participatory and pragmatism. As Avramidis and Smith (1999) commented

> … trying to categorise all educational and psychological research into a few paradigms is a complex, and perhaps impossible, task, … there is little paradigmatic purity and the fact that different labels are used in different texts, the task of identifying paradigms becomes even more perplexing. (p. 27)

However, a critical analysis by Mackenzie and Knipe (2006) shows most of the types of research paradigms used in educational research fall under four main common paradigms: positivism, postpositivism/interpretive, critical theory and pragmatism. These four research paradigms are discussed in the next sections and the paradigm of the best fit for this project is then identified

3.2.1.1 Positivist paradigm

The positivist paradigm is based on philosophical ideas developed by the French philosopher and sociologist August Comte in the early 19th century (Kim, 2003). According to Kim (2003) "Comte's conceptualization of positivism was based on scientific objectivity and observation through the five senses rather than subjective beliefs" (p. 11). The founders of positivism hold the notion that the only authentic knowledge is that based on sense experience and positive verification. Positivists advocate that reality is uncovered through application of the methods of the natural sciences (Bryman, 2008; Patton, 2002; Sarantakos, 2005). They claim that science provides the clearest ideal knowledge, and researchers should use scientific methods (such as observation, experimentation, hypothesis formation, data collection, forming theory/falsifying theory) as means of studying the subjective world (Bryman, 2008; Cohen et al., 2007). The literature (e.g., Bryman, 2008; Cohen et al., 2007; Dash, 2005; Guba & Lincoln, 1994) identifies the following key assumptions underpinning the positivist paradigm:

- Determinism- the view that events are caused by other circumstances; and hence, understanding such casual links is necessary for predicting and controlling the phenomena under study;
- Empiricism- the view that knowledge is obtained through collecting evidence (via scientific methods) and it provides the basis for laws, theories or hypotheses, which can be verified through observation or direct experience;
- Parsimony- which refers to explaining the phenomena under study in the most economical way possible; and

- Generalisability- which is considered an important value in doing research, with the main focus on generalizing the results from observation of the particular phenomenon to the world at large.

Positivists believe that only quantitative data are considered valid and of high quality (Guba & Lincoln, 1994), and that true knowledge comes from systematic quantification or manipulation of variables (Dash, 2005). The main role of positivist researchers is to test theories and provide data for the development of laws and principles (Cohen, Manion, & Morrison, 2011). Positivist education researchers employ a strict research plan designed prior to the commencement of the research that allows the replication of the inquiry processes. Proponents of the positivist approach argue that research should be conducted in a way that is value free, and they reject the idea that knowledge comes from values (Dash, 2005; Guba & Lincoln, 1994). They also believe that knowledge exists outside individuals or can be imposed from outside (Bryman, 2008). Positivism as a school of thought dominated social research for almost half of the 19th century. However, there has been something of a 'revolt' against positivistic assumptions in social science research. Critics argued that positivistic assumptions are inadequate for studying human behaviour (Cohen et al., 2011); in particular, for understanding the subjective states of individuals (Dash, 2005), because human behaviour and actions are complex, and cannot be quantified and studied by the rigorous randomization of variables (Guba & Lincoln, 1994). They suggest that objectivity of scientific investigation should be replaced by subjectivity (Dash, 2005). As a result of these criticisms, the interpretive paradigm has evolved to respond to the emerging complexity of social science research. The interpretive research paradigm is discussed in the next section.

3.2.1.2 Interpretive paradigm

Interpretivism represents the ideas developed by philosophers from their critique of the positivism paradigm. These ideas challenge the traditional positivism notion of knowledge as absolute truth. Interpretivist researchers believe that social reality is viewed and interpreted by the individual according to the ideological position s/he takes (Bryman, 2008; Creswell, 2009). According to Creswell

(2009) “individuals develop subjective meanings of their experiences ... meanings are varied and multiple, leading the researcher to look for the complexity of views rather than narrowing meanings into few categories or ideas” (p. 8). Thus, interpretivist researchers believe that there is no single reality—reality lies in the multiple perspectives of the participants and is inherently subjective. Interpretivism takes an epistemological position that respects individual differences and the social context of the social reality, and assumes that natural science is unable to explain the basis of social human life (Blaikie, 2007; Bryman, 2004; McKerchar, 2008). According to Sarantakos (2005), interpretivism is “concerned with views, opinions, and perceptions of people as they are experienced and expressed by everyday life” (p. 40). Thus, it requires social processes rather than those of natural science. As LeCompte and Schensul (2010) posit:

> ...reality differs, depending on whose reality is considered. Thus, different people have different versions of what is true; they even can have differing perspectives on the same events. What we “know,” then, is a function of our interpretation of events and the meanings we create to explain those events to others. Reality is, in a sense, “in our heads”. (p. 67)

This view of reality means that human beings are exclusively unique, active, and autonomous creatures in contrast to the positivist worldview that human beings are passive objects that can be manipulated (Schwandt, 1994). Interpretivists argue that research is a natural participatory process, and meanings of social phenomena are created through human interaction. An interpretivist researcher is involved in the investigation as a participant observer by immersing him/herself in the life of the research participants in order to observe the live events, and participating in social dialogue and social interaction (LeCompte & Schensul, 2010). This way of working helps the researcher to collect reliable and fresh or live data as reported by the study participants. Merriam (2002) commented that “learning how individuals experience and interact with their social world, the meaning it has for them, is considered an interpretive qualitative approach” (p. 4). The interpretive research paradigm thus usually uses qualitative research approaches and employs research designs such as case study, biographical research, phenomenology, ideology critique, action research and ethnography (Cohen et al., 2007; Creswell, 2009; Merriam, 2002). Data are collected using techniques such as unstructured interviews, participant observations and documentary analysis (Creswell, 2009; Livesey, 2006; Merriam, 2002). Qualitative research methods and data gathering techniques generally produce richly descriptive data in the form of words and pictures/images that allow the researcher to understand deeply the phenomena under investigation. The data from interpretive studies are usually presented in the form of quotes from documents, field notes, interviews and focus group discussion to support the authenticity of the findings of the interpretivist researcher.

3.2.1.3 Critical research paradigm

Critical theory ideas were first drawn from the writings of Karl Marx, Hubermas, Freire and the feminist emancipatory movement (Cohen et al., 2011; Weaver & Olson, 2006). Critical theorists are concerned with existing inequalities, oppression, disproportionate distribution of resources and political power within society. The proponents of the critical theory paradigm argue that both interpretivism and positivism inadequately account for social behaviour because they have neglected political and ideological contexts in conducting their educational research (Cohen et al., 2011). They assume that reality or knowledge does not accumulate in an absolute sense, but is the result of the exchange of logical arguments that erode the historical ignorance of the oppressed society. They believe that engagement in the "dialectical process causes an increased awareness of reality, and from this changes may occur" (Mokhele, 2011, p. 79). According to critical theory proponents the motives of the inquiry should focus on emancipation or transforming of society from oppression, repression, underrepresentation, and disempowerment (Guba & Lincoln, 1994; Peca, 2000; Weaver & Olson, 2006).

Critical theorists also assume that reality exists in specific historical and geographical contexts and can be captured in the cultural context of the society. The critical theorist researcher's role is more than describing or understanding the situation; it is to change it or take action by raising the awareness of the powerless people in the society (Cohen et al., 2011; Patton, 2002; Peca, 2000). The intent of critical theory-based research is influenced by political motives to help marginalized people, transform inequalities and create egalitarian democratic society/societies (Creswell, 2009; Hume, 2006; LeCompte & Schensul, 1999). Critical theorists put more emphasis on investigating sources of inequalities in the system and they work as an intellectual activist for changing a system's inequalities (LeCompte & Schensul, 1999). Since the intent is to change inequitable actions and oppressing policies (LeCompte & Schensul, 1999), both investigator and participants should have similar aims, objectives and values or agendas that they are pursuing.

According to Patton (2002), critical theory research studies "are oriented in a particular direction or framed from a specific perspective" (p. 131) and their inquiries are aimed at confirming and elucidating social problems instead of discovering social inequalities. The methodological approaches of critical theory research include action research and ideological critic (Dash, 2005; LeCompte & Schensul, 2010). Researchers using this paradigm believe that the action research approach brings people into reflective logical dialogue that allows them to work as collaborative researchers. In educational research action research is considered a professional development tool that helps to improve teachers' practice through "cycles of planning, acting, observing and reflecting" (Kember & Gow, 1992, p. 297). This model of research changes educational practice through social action (Kember & Gow, 1992), because it allows for the reflective process in professional learning (M. Levin & Greenwood, 2011). Thus, critical theory paradigm research focuses on questioning the status quo and changing the situation rather than just understanding existing situations.

There has been growing dissatisfaction recently among social researchers with "the use of a single qualitative approach to access meaning in data raises questions about what the use of another method would have illuminated in the data" (Frost et al., 2010, p. 2). Thus, they recommended the use of mixed methods or a pluralistic approach that complements the weaknesses of both qualitative and quantitative approaches to studying social phenomena (Creswell, 2009; Morgan, 2007). They believe that the use of a pluralistic approach where inquiry is conducted using more than one paradigm provides richer information that helps the researcher to understand deeply the phenomenon under study. Therefore, these critics have developed the pragmatism paradigm as a pluralistic or mixed approach for studying complex problems in research, and this pragmatism paradigm is discussed in detail in the next section.

3.2.1.4 Pragmatism research paradigm

Pragmatism is a new philosophical approach to inquiry that rejects the application of positivism, critical theory, and postpositivism/interpretivism in studying reality. The followers of this paradigm reject the notion of selecting a research paradigm and recommend the use of a pluralistic approach to studying research problems (B. Johnson & Onwuegbuzie, 2004; Lodico, Spaulding, & Voegtle, 2006). They argue that what is important for a researcher is not the choice of research method but what works best in order to uncover the research problem and provide answers (Creswell, 2009; Patton, 2002). They advocate mixing qualitative and quantitative research methods to study social phenomena (Creswell, 2009; B. Johnson & Onwuegbuzie, 2004; Morgan, 2007). For example, B. Johnson and Onwuegbuzie, (2004) argued that "research approaches should be mixed in ways that offer the best opportunities for answering important research questions" (p. 16). They argue that the mixing of research approaches results in superior research findings (B. Johnson & Onwuegbuzie, 2004), because results from two approaches are used as inputs to support each other (Morgan, 2007). Proponents argue that pragmatist researchers when studying social phenomena are usually guided by what best fits the context of a particular investigation (Morgan, 2007; Patton, 2002). Work by B. Johnson and Onwuegbuzie (2004) identify the tenets of the pragmatism paradigm:

- rejects traditional dualisms and generally prefers more moderate and commonsense versions of philosophical dualisms based on how well they work in solving problems;
- recognizes the existence and importance of the natural or physical world;
- has high regard for the reality and influence of the inner world of human experience in action;

- knowledge is viewed as being both constructed and based on the reality of the world we experience and live in;
- endorses fallibilism (current beliefs and research conclusions are rarely, if ever, viewed as perfect, certain, or absolute);
- views current truth, meaning, and knowledge as tentative and as changing over time; what we obtain on a daily basis in research should be viewed as provisional truth; and
- instrumental truth is a matter of degree (i.e., some estimates are more true than others). (p. 18)

Pragmatic researchers usually look for the middle ground between the philosophical dogmatism and scepticism in investigating social problems (B. Johnson & Onwuegbuzie, 2004; Morgan, 2007), and they consider truth to be what worked in that particular time and context (Creswell, 2009). For example, (Morgan, 2007) argued that pragmatist studies depend on '*abductive* reasoning'- where the researcher uses both induction and deduction reasoning approaches; *intersubjective reasoning* - where the researcher works back and forth between subjectivity and objectivity frameworks; and *transferability* of the findings to other contexts. These forms of reasoning are considered the main values underpinning pragmatic studies. Other researchers have argued that pragmatism directly links theory with praxis (M. Levin & Greenwood, 2011) , while Petrou (2007) concluded that "pragmatists are not committed to any philosophy and they cannot see the importance of discussing assumptions about truth and reality when designing their research. What is important to them is what works in practice" (p. 1740). Therefore, for the pragmatist researcher what is important in studying research problem is what works to answer the research questions. The next section reports the paradigm selected for this study.

3.2.1.5 The interpretive paradigm as paradigm of choice for this study

According to Maxwell (2008), selection of study paradigm "is not a matter of free choice" (p. 224), but depends on the researcher's prior assumptions about the world, topic of the study, and how the study can be easily understood by end users. Selecting the best research paradigm involves the process of assessing which paradigm best fits “your own research assumptions and methodological preferences” (Maxwell, 2008, p. 224). This study seeks to understand and interpret unqualified ‘licensed science teachers’ classroom teaching practices and their effectiveness in using learner-centred pedagogy in the natural setting of Tanzanian secondary schools classrooms. Understanding these teachers’ classroom teaching practices in their natural setting is likely to inform the researcher about licensed science teachers’ PCK training needs.

To achieve the purpose of this study the interpretive paradigm was adopted because its tenets allow the researcher to conduct a thorough investigation of the social phenomenon as reported by the study participants and how they interpret the meanings within their social cultural setting (Cohen et al., 2011; LeCompte & Schensul, 1999; Russett, 2008). It also allows the researcher to immerse him/herself in the subjective perceptions or lived experiences of the participant, which helps the researcher understand the culture, interactions, group norms and the reasons for their actions (Cohen et al., 2007; Denzin & Lincoln, 1994; Scott, 1996). In this study the researcher assumed that participants’ reality is mediated by humans’ interaction with their external world, such as the historical background and the cultural context in which they live (Golafshani, 2003; Grbich, 2007; McKerchar, 2008; Opie, 2004; Sarantakos, 2005; Stake, 2010). Since the purpose of the study was to discover how licensed teachers perceive reality and the reasons for their interactions during classroom teaching, this researcher believes that using the interpretive paradigm as a lens for the investigation will enrich the research process, because meanings in interpretive research are negotiated during the immersion of the researcher in the participants’ worldview (Becker & Bryman, 2004; Cohen et al., 2007; McKerchar, 2008; Sarantakos, 2005). Studying licensed science teachers’ actions and views using the interpretive research paradigm is likely to generate insightful data for understanding their perspectives on the world and the reasons for their classroom teaching practices.

This thesis adopted the interpretive paradigm because it allows one to study a small sample of participants in small-scale situations located within particular social and cultural contexts which are not known to the researcher and do not require application of prior theory (Grbich, 2007). For example, Cohen et al. (2007) affirm that interpretivist researchers “are dedicated to studying the individual in preference to the group” (p. 19). The emergent design characteristics of the interpretive paradigm (Jacobson, Gewurtz, & Haydon, 2007) help the researcher to be flexible in studying reality in an unknown context, where s/he does not have an in-depth awareness of what s/he going to investigate in advance. It is important to recognize that interpretive inquiries are not considered generalisable (Grbich, 2007); however, they can generate rich data, which allows what has been learned in one study to be useful in other settings with similar populations and similar social and cultural contexts (Russett, 2008; Teddlie & Yu, 2007). Hence, the researcher in this study believes that these findings may inform practice elsewhere about professional learning support for under-qualified teachers recruited using non-university-based approaches.

Finally, the collaborative nature of interpretive research processes (LeCompte & Schensul, 1999), including characteristics, such as reciprocal relationships between the researcher and participants, of negotiating meanings with participants “give interpretive inquiry its own power dynamics and thus its own ethical conundrums” (Jacobson et al., 2007, p. 2). These conundrums mean that ethics in interpretive research is a significant subset of the inquiry process, because, in order for the researcher to immerse him/herself in the participants’ world and give their perspectives a voice, the researcher and participants must mutually agree to the processes of investigation. The interpretivism paradigm has natural mechanisms for moderating ethical issues during the research process, and this gives the researcher an added advantage.

3.3 Suitability of qualitative inquiry as a research methodology for this study

The choice of research methodology depends on the nature of the research problem and questions (Creswell, 2009; Sarantakos, 2005; Seale, Gobo, Gubrium, & Silverman, 2004). Qualitative research methods are usually considered when the research aims to investigate a complex social problem that is difficult to be studied quantitatively, and where the researcher wants to generate the data necessary for understanding the social problem comprehensively (Curry, Nembhard, & Bradley, 2009). This study adopted the qualitative research methodology using the ‘case study design’ to explore the research problem because of the nature of the research problem and research questions which require in-depth investigation using participants’ natural setting (Bryman, 2008; Denzin & Lincoln, 1994). As Denzin and Lincoln (1994) commented, qualitative researchers “study things in their natural settings, attempting to make sense out of, or interpret phenomena in terms of the meaning people bring to them...it involves collection of variety of empirical materials—case study, personal experiences...” (p. 2). The qualitative methodology was considered suitable for other reasons as well: first, it allows the researcher to focus on one idea to be explored or understood, and it can use a single case or a few participants (Creswell, 2009; R. B. Kaplan & Maxwell, 2005); second, the data sources are well grounded, contain rich descriptions and provide an explanation of processes that are occurring in the local context (Lincoln & Guba, 1985; Miles & Huberman, 1984, 1994); third, the human investigator is the primary instrument for data collection (Cohen et al., 2007; R. B. Kaplan & Maxwell, 2005; Lincoln & Guba, 1985; Miles & Huberman, 1994); fourth, there is an assumption that social reality and meaning are constructed; and the researcher can gain a holistic overview of the problem under study (Cohen et al., 2011; Creswell, 2009).

Qualitative methodology uses multiple data collection instruments and sources of data such as interviews, focus group discussion, observation and documentary review (Borg, Gall, & Gall, 1993; Cohen et al., 2011). The use of multiple sources of data according to Patton (2002) strengthens the study by a process called ‘triangulation’. Triangulation, according to Bryman (2008), is using “more than one method or source of data in the study of social phenomena” (p. 379). This study generated qualitative data using one-to-one interviews and focus group discussions with licensed science teachers and classroom observations of their teaching to obtain their views on classroom practices. The researcher interviewed school headmasters and district education officers, a ward education officer and a regional school inspector for the purpose of triangulating teachers’ views in order to collect richer information about teachers’ classroom teaching practices. Also, the documents relating to the licensed science teachers’ practices were analysed to enrich the data collected from interviews and focus group discussion. Using multiple instruments to collect in-depth information from different sources is considered instrumental in increasing the trustworthiness of the study.

3.4 Suitability of case study as a research design of this study

The research design is the plan or strategy of investigation conceived to seek answers for research questions (Blaikie, 2010; Bryman, 2008). A case study involves "an intensive description and analysis of a phenomenon or social unit such as an individual, group, institutions or community" (Merriam, 2002, p. 8). Yin (2009) suggested that a case study design should be considered when: (a) investigating a contemporary event where the researcher cannot manipulate the behaviour of the participants; (b) the focus of the study is to answer 'how' or 'why' research questions; (c) the researcher has a little or no control over the contextual factors that are relevant to the study; and (d) there are no clear boundaries between the phenomenon and context. Yin (2009) identified two types of case study: the 'single-case study design' and the 'multiple-case study design'. The single-case study design refers to the investigation of a single participant or individual case at a time. In contrast, multiple-case study design refers to investigation of more than one participant or multiple events at one time (Merriam, 2002; Yin, 2009).

This study adopted a case study design for the following reasons. First, a case study is best for investigating the research problem in its natural setting (Yin, 2009); in this study the researcher did not want to manipulate the licensed science teachers' behaviour in the classrooms. Second, the case study allows the researcher to provide a 'thick' and detailed description of the research problem, which would help the researcher to understand the events and practices of licensed science teachers in their community secondary schools in Tanzania and their professional learning needs. In this study, the researcher conducted intensive interviews, focus groups discussions, and classroom observation to collect detailed data about licensed science teachers' classroom practices. Rowley (2002) observed that the case study "supports deeper and more detailed investigation" (p. 17) of the research problem. Third, the case study design allows the researcher to investigate complex real-life activities using a holistic approach, and it uses multiple sources of evidence (Cohen et al., 2011; Noor, 2008; Yin, 2003). In this study the researcher collected data using four different sources of data: interviews, focus group discussions, classroom observations and a review of documents or artefacts relating to licensed science teachers' classrooms teaching.

The data for a case study are usually generated from individuals, groups or communities of participants using verbal reports (in-depth interviews, focus group discussions), participant observation, and documentary analysis or any combination of these (Yin, 1981) in line with interpretivist data collection methods (Cohen et al., 2011; Merriam, 2002). The use of multiple data collection instruments and the choice of a multiple case study design are considered important for strengthening the authenticity of the qualitative interpretivist inquiry. As Yin (2009) suggested, the multiple-case study design increases the rigour of the inquiry. This study conducted intensive 'case studies' of six licensed science teachers and each teacher was interviewed once and observed in classroom twice before and after the PDI. In addition, for the purpose of enriching the data, two focus group discussion sessions were conducted involving the teachers, one before and one after the PDI. Two heads of school, one ward education officer, one regional school inspector, and two district education officers also participated in one-to-one interviews.

3.5 Sampling procedure

According to Cohen et al. (2011) in qualitative research sampling the "emphasis is placed on the uniqueness, the ideographic and exclusive distinctiveness of the phenomenon, group or individual in question, i.e. they only represent themselves, and nothing or nobody else" (p. 161). Qualitative researchers usually apply nonprobability sampling using purposive sampling techniques (Adler & Clark, 2008; Ary, Jacobs, Razavieh, & Sorensen, 2010; Cohen et al., 2011; Flick, 2008). According to Cohen et al. (2011) in the non-probability sampling method the "sample derives from the researcher targeting a particular group, in full knowledge that it does not represent the wider population; it simply represent itself" (p. 155); and, in purposive sampling, the "researcher selects sampling units based on his or her judgment of what units will facilitate an investigation" (Adler & Clark, 2008, p. 121). Purposive sampling is the technique mainly used in naturalistic inquiry studies, and is defined "as selecting units (e.g., individuals, groups of individuals, institutions) based on specific purposes associated with answering a research study's questions" (Teddlie & Yu, 2007, p. 77). It helps the researcher to focus on key informants, who are particularly knowledgeable about the issues under investigation (Schutt, 2006), because purposive sampling allows judgmental decisions about the selection of participants to be made (Ary et al., 2010; Bernard, 2000). In addition, it allows the researcher to decide why she or he wants to use a specific category of informants in the study (Bernard, 2000), and it provides greater in-depth findings than other probability samplings methods (Cohen et al., 2011). Ary et al. (2010) reported that the purposive sampling method fits well when studying individual cases. Schutt (2006) suggested three key features to consider in selecting informants using the purposive sampling technique. First, the informants should be knowledgeable about the social problem to be studied and have experience of it. Second, they should be willing to provide the needed information; and third, they should represent a wide range of the population.

In this study the purposive sampling approach was used because of the following key advantages: first, it allowed the researcher to study the phenomena without the advanced unit of analysis for investigating the phenomena being pre-determined; second, it allow the researcher to conduct a pilot study before doing a full investigation; and finally it can be used in studying critical cases that require only a few participants, or even a single participant (Bernard, 2000). In this study, the purposive sampling framework was used to select five schools performing poorly in science subjects in Manyara Region as case study schools, because most of these schools have a shortage of teachers and depend on the recruitment of unqualified licensed teachers. From these schools, the researcher then purposively selected a group of unqualified licensed science teachers and their immediate supervisors as study participants. Since participation in this study was based on willingness, only those licensed science teachers who had accepted the invitation were involved in this study. The researcher assumed that licensed science teachers would have experiences to share in the due course of this study because they had been working as untrained or unqualified teachers recruited through the alternative route approach. In addition, the study assumed that the licensed science teachers' immediate job supervisors (headmasters, district educational officers, ward educational officers, and regional school inspectors) and students would have views and knowledge to share that were important for understanding licensed science teachers' classroom practices and the challenges facing them in the teaching profession. That is, the licensed science teachers' immediate supervisors and students were considered to be knowledgeable informants (Cohen et al., 2011; Schutt, 2006), and were another group for this case study. Therefore, the purposive sampling approach is good for the selection of participants.

3.5.1 Accessing study participants

Having decided to use purposive sampling for selecting participants, other factors influencing the choice of the sample included accessibility of schools, school performance in science subjects, and distance between schools. With these variables in mind, the researcher visited the National Examination Council of Tanzania (NECTA) database to find out which schools had performed poorly in science subjects in Babati district. Babati district was selected for this study because the researcher is a native of Babati district and is aware of its culture and this was considered useful for building trust with the study participants. From the NECTA database the researcher identified five secondary schools that had performed poorly in science subjects for two consecutive years. Also, the close proximity between the schools was an added advantage in making the final decision about school selection, as this was considered an important factor for facilitating the teachers' professional learning network during the intervention.

The researcher's four years of experience as a secondary school teacher at Bashnet secondary school and being a native of Babati district were helpful in accessing informants and getting to know the schools' geographical area. The researcher received strong support from the district education office as the district education officer was a former teacher of the researcher in the teacher training college; some of the schools' headmasters were the researcher's previous teachers when he was a student in junior secondary school, and other headmasters/mistresses had worked with the researcher as teachers in the district. Some of the licensed teachers were also former secondary school pupils of the researcher. This previous experience was very helpful to the researcher, particularly in accessing participants, but more importantly it helped the researcher build trust with participants of the study. This may have motivated some of the teachers to agree to take part in this study. As Schutt (2006) and Jacobson et al. (2007) observed, building trust with respondents during the research process is an important feature in interpretive research because it helps the researcher understand participants' worldview.

3.5.2 Obtaining official authorization to access schools

Before going to the respective schools the researcher approached the Principal Secretary of the Ministry of Education and Vocational Training (MoEVT) requesting permission to access Tanzanian's secondary schools for the study. At this meeting the researcher presented the secretary with a research clearance letter (see Appendix 1). After two days the researcher received authorization letters (see Appendix 2) to enable him to gain access to all secondary schools in Manyara Region. The letter from the MoEVT required the researcher undertaking the study to get permission from the Manyara Regional Administrative Officer before accessing schools, so the researcher submitted the authorization letter from MoEVT to the Manyara Regional Administrative Officer asking permission to access the schools. The Regional Administrative Officer granted permission to access the schools (see Appendix 3) by introducing the researcher to the District Administrative Officer. The researcher then visited the Babati District Administrative Officer with an introductory letter from the Regional Administrative Officer requesting him to allow the researcher to access the schools. The District Administrative Officer also granted the researcher permission (see Appendix 4) to access schools by introducing him to the Babati District Education Officer, who subsequently granted the researcher permission (see Appendix 5) to access schools by introducing him to the heads of schools.

With the authorization letters from the above authorities, the researcher visited four selected schools personally, met the headmasters/mistresses (heads of schools) and verbally requested permission for their schools to be involved in this study. Those headmasters who granted permission were given research clearance letters from the Ministry of Education, Regional and District Administrative officers, and a formal official request letter for their schools' participation in the study. All four secondary schools that were first approached accepted the request and no further schools were approached. The headmasters of these schools were then given invitation letters for the schools (see Appendix 6). For the purpose of this study the names of these schools are: Tlawi, Katani Nungu, and Hewasi. These are not the real names but pseudonyms for easy reference in this study and to abide by ethical research standards.

After getting official permission from the headmasters the researcher arranged an initial meeting with the individual licensed science teachers and talked about the study. Those licensed teachers willing to participate were given official invitation letters (see Appendix 7). During the initial meeting the purpose of the study and the participants' rights were discussed. It was made clear during this discussion that participation was on the basis of willingness, and that any participant had the right to withdraw from the study at any time or not to participate in this study at all. This first briefing meeting was attended by 11 teachers and they were given invitation letters after verbally accepting the invitation to participate. The researcher left them with the informed consent form (Appendix 8) overnight to give them more time to reflect on the purpose of the study individually. Seven licensed science teachers signed the informant consent form, and four teachers did not return the informed consent form. None of the teachers were coerced. However, at the early stages of the research one teacher dropped out from the study because of a family problem, and another dropped out during the second phase of the study- the five remaining licensed science teachers participated in the study fully.

3.5.3 Case study schools

This case study was undertaken in four schools: Katani, Hewasi, Nungu and Tlawi (all pseudonyms). The study involved two teachers from Katani secondary school, two teachers from Hewasi secondary school, one teacher from Nungu secondary school, and one teacher from Tlawi secondary school. The profile of each school and the teachers are shown in Table 2. The six licensed science teachers were all interviewed and they participated in the PDI designed to enhance their PCK. Two out of the four experienced headmasters were invited to participate in individual interviews about licensed science teachers' practices in their schools and they all accepted. These four schools were used as 'case study' centres for this study and their backgrounds are presented in the next section.

3.5.3.1 Backgrounds of sample schools

Katani secondary school. The school had a total of 325 students, 11 classrooms and 12 teachers. The school had a deficit of two chemistry, two physics and two biology teachers and had recruited two licensed science teachers to cover the shortage. Some classes were found to have as many as 80 students because teachers were combining two classes of students to cover the teacher shortage. The school did not have a working science laboratory or demonstration classrooms for science, with the result that teachers teach science without any practical work.

Tlawi secondary school. The school had 654 students of which 362 were girls and 292 boys. The school has 13 qualified teachers and five licensed teachers (four are science and mathematics teachers and one was an arts subject teacher). The school had a deficit of two chemistry teachers, one biology teacher and one physics teacher. The school campus had 15 classrooms and three laboratory buildings, but none of the laboratories has the equipment necessary for conducting science practicals. Due to the shortage of teachers, the few available teachers sometimes combined two classes of students, which caused some classes to be overcrowded with an average of 70 students per classroom.

Table 2: *Sample schools*

Name of school[1]	Pseudonym of teacher	age	Teaching subjects	Lessons observed before PDI	Lessons observed after PDI	Teacher's academic qualification	Teaching experience (years)
Tlawi	Manimo	23	Mathematics	1	2	Advanced certificate of secondary education/registered	5
			Physics	1	-[2]	student at Open University of Tanzania	
	Pombe	25	Biology	2	2	Advanced certificate of secondary education/registered student at Open University of Tanzania	5
Nungu	Tiita	26	Physics	1	2	Advanced certificate of secondary education/registered	4
			Chemistry	2	-	student at Open University of Tanzania	
Katani	Sungura	31	Physics	2	-	Advanced certificate of secondary education/	3
			Biology	1	-	absconded studies from the University of Dar es Salaam	
	Safari	20	Chemistry	1	1	Advanced certificate of secondary education	1
Hewasi			Biology	1	-		
	Qwary	19	Biology	1	-	Advanced certificate of secondary	1
			Chemistry	1	1	education	
			Physics	1	-		
			Mathematics	-	1		
Total number of lesson				15	9		

[2] Dash means the lesson was not observed because teacher was not teaching the particular subject that term

Nungu secondary school. The school had 755 junior secondary school students, 95 senior secondary school students, and 32 teachers. There were 18 classrooms but no science laboratory. This school has many teachers compared with the other case study schools because it is located in the town centre and most teachers preferred working in an urban area (Mulkeen & Chen, 2008). The school currently has a deficit of two physics teachers and one chemistry teacher, and the school management has recruited one licensed science teacher to fill the gap.

Hewasi secondary school. The school had 368 girls and 332 boys. The school had a total of 22 permanently employed teaching staff, including five graduate teachers, 17 diploma teachers, and three temporarily employed Form Six leavers who were teaching science and mathematics. The school had a shortage of three chemistry teachers, two mathematics teachers, two physics teachers, and three biology teachers. There were 11 classrooms and five more classrooms were needed to accommodate all the students at an average of 40 students per class. However, the shortage of classrooms meant most of the classes had an average of 70 students. The school did not have a science laboratory. The next section reports on the phases of this study.

3.5.4 Research timing/phases

This study was conducted in two phase. In the first phase, the researcher engaged in some personal professional learning in the pedagogical approaches and strategies used to promote learner-centred teaching in teacher education. The researcher was invited by one of his thesis supervisors to observe her teaching three science and education papers or courses: the first paper was *Classroom Perspectives in Science Education* which is an undergraduate paper intended to enhance the PCK of pre-service primary science education student teachers enrolled in a teacher education degree programme at the University of Waikato; the second paper was *Secondary Curriculum Scienc*e, which an introductory paper again for secondary pre-service teachers; and the third paper was *Secondary Curriculum Chemistry*, a postgraduate teacher education paper intended to enhance the PCK of pre-service secondary chemistry teacher education students.

The course lecturer exposed student teachers to a constructivist learning and teaching environment on the assumption that student teachers are active learners and they construct knowledge themselves (Schunk, 2012). According to the constructivist theory, human cognition processes such as thinking and learning are influenced by the physical and social context (Greeno, 1989; Schunk, 2012). Thus, teachers' construction of knowledge and learning is the result of interactions within a context (situativity learning) and also when learners learn in collaborative groups in a specific social context such as a school community. The researcher attended the course instruction workshops over a three month period and observed a range of learner-centred pedagogical practices by the lecturer. From time to time the researcher participated as a student teacher. The researcher was mentored by the supervisor in the various techniques used to enhance pre-service teachers' PCK using constructivist and sociocultural views of teaching and learning. The mentoring helped the researcher to gain further knowledge, skills and strategies for enhancing pre-service teachers' PCK for the purpose of teaching science in primary and secondary schools. The lecturer in the primary education paper used strategies of primary school classroom with herself role-playing the teacher and the student teachers as primary students. Similar strategies were used in the secondary science paper where student teachers were introduced to learner-centred teaching strategies.

Attending the teacher education workshops proved to be very useful for the present study because the researcher deepened his understanding of learner-centred workshop strategies and philosophies that related to science teaching. The knowledge and experience gained were used to develop the draft PDI programme for licensed science teachers (see Appendix 9). The researcher also obtained, and later he thought were culturally relevant, resources, ideas, and strategies used by the course lecturer in science education papers for enhancing licensed science teachers' PCK in the Tanzanian context. Culturally responsive teaching "creates a learning context that is responsive to the culture of the child and means that learners can bring who they are to the classroom in complete safety and where their knowledge is acceptable and legitimate (Bishop, Berryman, Cavanagh, & Teddy, 2009, p. 741). Significantly, the perspective that human construction of knowledge and learning are inherently influenced by the context underpinned the design of the PDI to suit the Tanzanian context. Schunk (2012) pointed out "situated cognition fits well with the constructivist ideas that context is an inherent part of learning" (p. 234).

Synchronously, the researcher engaged in an in-depth literature review to identify factors that are reported to make teachers' professional development effective. By examining various models and principles of teachers' professional development, the researcher found agreement in the literature that in order for PDI to have a positive impact on teachers' practices, a needs assessment should be conducted before teachers were involved in the intervention (Guskey, 2000; Loucks-Horsley et al., 1996). This finding from the literature review resulted in an assessment of licensed science teachers' professional learning needs whereby the researcher became immersed in assessing licensed science teachers' PCK needs. The licensed science teachers' PCK needs assessment was conducted by directly involving them in the process of identifying their professional learning needs and involving their immediate supervisors such as headmasters/mistresses and district education officers. The professional learning needs assessment of licensed science teachers was conducted through interviews, focus group discussions, documentary review and classroom observations. The PCK needs identified during this process of investigation form the first phase of the findings and these are presented later in Chapter 4 of this thesis.

The professional learning needs of licensed science teachers identified during the first phase of this study, in particular those relating to PCK, resulted in the second phase of this study. The second phase of the study focused on strategies for addressing the PCK needs whereby the researcher designed and presented a draft PDI programme for the licensed science teachers. Viewing this draft allowed the licensed science teachers to comment on whether or not they felt the content of this proposed programme could meet some of their PCK needs. Corcoran (1995) argued that good professional development of teachers "should draw on the expertise of teachers and take differing degrees of teacher experience into account" (p. 3). They evaluated the draft of the PDI programme, rearranged the topics according to their immediate needs and use in the classroom, and suggested the order of implementation (see Table 5, chapter 5). Some concepts, such as teachers' PLCs and the conception of teaching were new to licensed science teachers and so they felt unable to comment; however, they provided some valuable inputs in areas where they felt partially knowledgeable but untrained, such as the planning and preparation of competency-based lessons. These findings are presented later in chapter 5 of this thesis.

3.6 Data collection methods

This study employed semi-structured interviews, focus group discussions, classroom observation, and documentary analysis as data collection methods. Data were also generated from reflective discussions during PDI workshops, and after each professional development workshop teachers were given evaluation papers to describe the effectiveness of the PDI in meeting their PCK needs. The data of this study were collected in two phases. The first phase data were collected in the following order:

- Classroom observations before the PDI;
- One-to-one in-depth interviews with the licensed science teachers before the PDI;
- One-to-one in-depth interviews with the headmasters, district education officers, ward education officers and regional school inspectors before the PDI;
- One focus group discussion with the six licensed science teachers before the PDI;

The second phase data were collected in the following order:

- Professional development workshops and teachers' written reflection notes from each professional development workshop;
- One focus group discussion with licensed science teachers after the PDI;
- Classroom observations eight months after the PDI to examine changes in teachers practice;
- Four sessions of focus group discussion with students eight months after the PDI.
- Teachers were given reflective questions eight months after the PDI for self-evaluation of the intervention in meeting their PCK needs (see Appendix 10)

These qualitative data generation methods are discussed in detail in Sections 3.6.1-5.

3.6.1 Classroom observations

Observation is defined as "systematic watching of behaviour and talk in naturally occurring settings" (Pope & Mays, 1995, p. 43). Observational data are attractive because they provide the researcher an opportunity to gather data in the natural setting (Cohen et al., 2011; Miles, 1979), and the approach is useful when the study objectives seek to understand the phenomena in a cultural setting hidden from and not known by the public or when the participants under investigation have different views from the public at large (Curry et al., 2009; Lambert & McKevitt, 2002). Data generation via observations offers the researcher an opportunity to understand the actual events that are happening in situ, rather than depending on others peoples' accounts, and thus is thought to yield more authentic and reliable data (Cohen et al., 2011; Merriam, 2002; Robson, 2002). These methods provide reality checks of what people say, as people often do different things to what they say or what they intend to do (Kawulich, 2005; Robson, 2002). Morrison (1993) suggested that observation enables the researcher to gather data about four aspects: first, the physical setting, for example, the school physical environment; secondly, the human setting, for example, the organization of people and characteristics; thirdly, classroom interactional settings, such as observing formal and informal interactions, planned and unplanned, and verbal and non-verbal interactions that are happening in the participants' natural context; and finally programme setting, for example, pedagogic styles, and curriculum implementation practices.

Robson (2002) suggested three forms of observational data collection. These forms are: the *participant observation* method, which is mainly used by qualitative researchers; the *structured observation* method, which is mainly used by quantitative researchers; and the *unobtrusive observation* method, which is non-participatory as well as non-reactive to the observed (Lee, 2000), and falls between the two extremes of the other methods. The participant observation method is defined as a "data collection technique that requires the researcher to be present at, involved in, and recording the routine daily activities with people in the field setting" (Schensul, Schensul, & LeCompte, 1999, p. 91), while unobtrusive observation is where the participants are unaware of being investigated or observed by the researcher.

This study employed the participant observation technique to examine licensed science teachers' classroom practices. This technique was useful in this case study because it enabled the researcher to access participants' "social and symbolic world through learning their social conventions and habits, their use of language and non-verbal communication" (Robson, 2002, p. 314), which are important in understanding the subjective meanings and experiences constructed by the participants. The researcher took the role of a complete participant observer (Cohen et al., 2011; Robson, 2002), as his presence was known to the study participants and students in the classroom.

The participant observation for this study was split into two phases. The first phase was conducted before the PDI, and the second phase after the intervention. The first phase of the classroom observation was conducted in order to observe the licensed science teachers' classroom practices and evaluate their ability to teach science lessons using learner-centred pedagogy. Also, the first phase of classroom observations contributed to gaining an understanding of the licensed science teachers' professional learning needs. Likewise, the second phase of classroom observation was conducted after the PDI in order to evaluate whether teachers' practices had changed because of the PDI. These classroom observations were considered vital in determining the effectiveness of the PDI. On average four lessons were observed in total for each licensed science teacher in each case study school. Detailed field notes were taken during the classroom observation of each lesson, and focused on teacher-student interactions and the nature of the classroom environment. Some lessons were audio-taped for the purpose of scrutinizing teacher talk during teaching.

3.6.2 Interviews

Interviewing is a qualitative data collection technique that involves collecting data through verbal interactions between an interviewer and the interviewee (Denscombe, 2007; Rubin & Rubin, 2005; Seidman, 2006). According to Seidman (2006), interviews are conducted when the researcher is interested "in understanding the lived experiences of other people and the meaning they make of that experiences" (p. 9). Interviews are a "very good way of assessing people's perceptions, meanings, definitions of situations and constructions of realty" (Punch, 2005, p. 168). Punch (2005) and Robson (2002) classified interviews into three main types: fully structured interviews, focused/semi-structured interviews, and unstructured interviews. This study adopted a semi-structured interview approach to obtain data from the participants (Appendix 11) because it enabled the researcher to collect specific information relevant to the study (Punch, 2005; Robson, 2002). Kvale and Brinkmann (2008) defined a semi-structured interview "as an interview with the purpose of obtaining descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena" (p. 3). Semi-structured interviews are best when the researcher intends to collect specific information from study participants (Merriam, 2002). Also, semi-structured interviews work well in projects where the researcher is dealing with busy people, such as education managers, teachers, and government bureaucrats, and helps the researcher to manage time efficiently (Bernard, 2000).

The study involved six licensed science teachers in in-depth interviews to explore their PCK needs and the strengths and constraints of the professional development that was available to them in their schools. The interviews were conducted in the teachers' schools and each interview was audio-taped. Also, in-depth interviews were conducted with two heads of schools (Appendix 12), one ward education officer (Appendix 13), two district education officers (Appendix 14) and one regional school inspector (Appendix 15). The interviews with headmasters and education officers were held in their offices. All interviews were audio-taped and transcribed verbatim to preserve the originality of information, increasing the trustworthiness of the data and for data coding purposes (Lincoln & Guba, 1985). The interview themes probed the education administrators' views about possible factors that could facilitate the establishment of PLCs in schools. Their views were used to inform the development of the PDI.

The interview questions were translated from English into Kiswahili because English was the third language of all the participants in this study, and this translation enabled them to communicate issues relating to the themes of the study more easily. The researcher conducted the interviews in Kiswahili to help the participants to relax and provide richer and detailed information about licensed science teachers' professional learning needs. The interview questions were translated by two members of the academic staff in the department of English and foreign languages, and one senior lecturer with experience in teacher education at the University of Dar es Salaam. Each member translated the questions individually and then met as a discussion group to produce a final draft of the Kiswahili version. This group discussion helped to assure coherence in the translation of the research instrument and ensured reliability and validity of the translated interview and focus group discussion questions. These translated Kiswahili research instruments were used to conduct interviews and focus group discussion with licensed science teachers, district education officer, headmasters and school regional inspector.

3.6.3 Focus group discussion

Focus group discussion is a qualitative research method used to collect in-depth group attitudes, perceptions and experiences from a specific group of people in their own language on a defined topic (Cohen et al., 2007; Robson, 2002; Stewart, Rook, & Shamdasani, 2007). Focus group discussion is defined as a "method of group interview which explicitly includes and uses group interaction to generate data" (Pope & Mays, 1995, p. 43) guided by the researcher. This method helps the researcher to understand the hidden insights that are difficult to unveil through straight forward interviews or discussion (Hydén & Bülow, 2003).

Focus group discussion is also useful to a researcher because: it helps gather data in very short time and lessens the cost of data collection; it encourages group views about the social phenomena under study rather than individual views; it empowers the participants by allowing them to comment on their own opinions and views; and it has natural control mechanisms of data collection because the participants themselves tend to provide views to balance extreme opinions during the discussion (Bernard, 2000; Punch, 2005; Robson, 2002). Kitzinger (1995) reported that during focus group discussion participants have the opportunity to speak, ask questions of other participants and respond to the comments of others, including the researcher, and so it is a natural checks and balance mechanism that leads to authenticity of the data collected. This study involved six licensed science teachers in two focus group discussions. One focus group discussion was conducted before the PDI (Appendix 16) and another after the PDI (Appendix 17). Four sessions of students' focus group discussions were conducted after the PDI, one from each of the four case study schools, to examine whether or not teachers were using learner-centred instruction after the intervention (Appendix 18). Both focus groups sessions were recorded to retain their originality and so that the participants could validate the transcribed responses.

3.6.4 Documentary analysis

According to Cohen et al. (2011), a document is defined as a "record of an event or process" (p. 248). Documents provide rich information that cannot be revealed through interviews, focus group discussions or observation (Patton, 2002). This study evaluated teachers' lesson plans, schemes of work, and student assessments as commonly used classroom artefacts in the teaching and learning process. The documents were analysed to collect evidence of teachers' professional learning needs and professional growth for each case study. Also the evidence collected from the documents was used to develop the PDI programme. The next section gives a detailed description of the professional development, which was a programme, designed as an intervention.

3.6.5 Professional development intervention programme

The study involved six licensed science teachers in the development, implementation and evaluation of professional development training aimed at meeting their professional learning needs identified during interviews, focus group discussion, classroom observations and documentary analyses. Teachers from the four case study schools participated for one month in professional development workshops, which took place in the Babati district teacher resource centre, Tanzania, as workshop meeting centre. The workshops were conducted for two days (Thursday & Friday) each week for a total of eight days. The workshop session was conducted for four hours per day and teachers reported at the centre around 10.00 am each workshop day. The workshop sessions were spaced to give teachers adequate time to practise the skills learned during workshops. After every workshop session teachers were asked to write their evaluation of the workshop and these reflective writings were collected on the day of the next workshop. The licensed science teachers were given two papers to read, one week in advance of each workshop day. These papers were compiled from different educational journals and those selected were considered the most useful for meeting licensed teachers' PCK needs (Appendix 9) that were identified. Teachers were required to summarize each paper for presentation at the workshops.

The PDI involved licensed science teachers in individual presentations and group discussions followed the researcher's presentation. Every week before the start of the professional development workshop, teachers were involved in a 20-minute reflective discussion focusing on the challenges they had come across during the implementation or trying out of the new skills they had learnt. The researcher also provided licensed science teachers with self-evaluation questions (Appendix10) after eight months of the intervention to obtain feedback about individual teacher's views on the effectiveness of the intervention in meeting their professional learning needs. The reflective discussion was considered an opportunity to obtain feedback about the PDI as perceived by the participants and these views are reported in Chapter 5.

3.7 Ensuring trustworthiness of the study

One of the challenges of qualitative research is how the researcher can ensure the results of the inquiry are trustworthy (Guba, 1981; Halldórsson & Aastrup, 2003; Lincoln & Guba, 1985). According to Holloway and Wheeler (2002) trustworthiness is assessed on the basis of methodological aspects (research design, data gathering, data analysis) accuracy (soundness) and adequacy of the qualitative research. In quantitative studies, the quality of research is usually ensured using quantitative criteria, such as reliability, external validity, internal validity and objectivity (Halldórsson & Aastrup, 2003). In contrast, in qualitative studies the trustworthiness or quality of research is ensured using criteria such as transferability, credibility, confirmability and dependability (Guba & Lincoln, 1982; Tobin & Begley, 2004). For example, Guba and Lincoln (1982) suggested that for a qualitative study quantitative criteria like "the concept of internal validity should be replaced by that of credibility, external validity by transferability, and that of reliability by dependability and objectivity by confirmability" (pp. 3-4). These qualitative criteria of trustworthiness are discussed in detail in the next sections.

3.7.1 Credibility

Credibility is defined as the confidence that can be placed in the truth of the research findings (Holloway & Wheeler, 2002; Macnee & McCabe, 2008). Credibility establishes whether or not the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views (Graneheim & Lundman, 2004; Lincoln & Guba, 1985). Thus, to ensure credibility of this study, the researcher adopted techniques suggested by Lincoln and Guba (1985): viz., prolonged field engagement where the researcher invested more time in the field to understand factors that might affect the credibility of the results, such as school culture, testing possible distortions of information by the respondents and also building the trust of the research participants. Second, the researcher undertook persistent prolonged observation to learn about and identify characteristics and elements that were most important for understanding the context of the problem and obtaining detailed information. Third, member checks where participants were given the interpreted data for evaluation to examine the authenticity of the researcher's interpretation of the data; and finally triangulation of the data collection instruments to examine whether or not there was convergence or divergence of the findings. Bouchard (1976) argued that the convergence or divergence of research findings "enhances our beliefs that the results are valid and not a methodological artefact" (p. 268). The researcher employed different research instruments, such as interviews, focus group discussion, classroom observation and documentary review, to generate rich data (Farmer, Robinson, Elliott, & Eyles, 2006; Golafshani, 2003; Halldórsson & Aastrup, 2003).

3.7.2 Transferability

Transferability refers to the degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents – it is the interpretive equivalent of generalizability (Bitsch, 2005; Tobin & Begley, 2004). According to Bitsch (2005), the "researcher facilitates the transferability judgment by a potential user through 'thick description' and purposeful sampling" (p. 85). In order to promote transferability, this study used the following strategies: first, the researcher collected rich and detailed data for the problem under investigation and provided thick descriptions of the context, methods and finding of the study (Bitsch, 2005; Lincoln & Guba, 1985); second, the participants were selected through purposive sampling (Gray, 2009; Li, 2004; Wallendorf & Belk, 1989); and third, triangulation of the study occurred across different (site) locations (Wallendorf & Belk, 1989). The study was conducted in four case study locations and participants were purposively selected to fit the milieu of the study.

3.7.3 Dependability

According Bitsch (2005), dependability refers to "the stability of findings over time" (p. 86). Dependability involves participants' evaluation of the findings, interpretation and recommendations of the study such that all are supported by the data as received from informants of the study (Cohen et al., 2011; Tobin & Begley, 2004). To promote dependability in this study, the researcher adopted the following strategies: first the use of an inquiry audit trial (Baxter & Eyles, 1997; Bryman, 2008; Guba, 1981; Guba & Lincoln, 1982). An audit trail here involves an examination of the inquiry process and product to validate the data where a researcher accounts for all research decisions and activities to show how data were collected, recorded and analysed (Bowen, 2009; Li, 2004). The audit trail also establishes confirmability of the study (Guba & Lincoln, 1982; Lincoln &

Guba, 1985; Tobin & Begley, 2004). Secondly, the achievement of the dependability criteria through observation of the informants for an extended period of time in order to learn of any changes and the explanations for changes (Wallendorf & Belk, 1989). In this particular study the researcher returned to the field work six months after the PDI to seek respondents' authentication of data. The professional development evaluation data were generated eight months after the previous meetings.

3.7.4 Confirmability

Confirmability refers to the degree to which the results of the inquiry could be confirmed or corroborated by other researchers (Baxter & Eyles, 1997). Confirmability is "concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but are clearly derived from the data" (Tobin & Begley, 2004, p. 392). Studies suggest that confirmability of qualitative inquiry is achieved through an audit trail (Bowen, 2009; Li, 2004; Lincoln & Guba, 1985). According to Bowen (2009) an "audit trail offers visible evidence—from process and product—that the researcher did not simply find what he or she set out to find" (p. 307). Confirmability also can be established using a reflexive journal (Koch, 2006; Wallendorf & Belk, 1989). Wallendorf and Belk (1989) described a reflexive journal as "reflexive documents kept by the researcher in order to reflect on, tentatively interpret, and plan data collection" (para. 77). The researcher in this study adopted important aspects of the audit trail as suggested by writers like Bryman (2008) and Lincoln and Guba (1985) and Tobin and Begley (2004). These aspects include keeping records of raw data, triangulation of data collection methods and use of a researcher reflexive journal (Li, 2004; Wallendorf & Belk, 1989). The researcher in this study kept electronic records (tape recorded) and non-electronic (i.e., field notes, documentary materials) during the whole investigation. These records helped to cross-check the data and writing of the final report of the study.

3.8 Data analysis

In a case study research design using qualitative research methods, data analysis is inseparable from the data generation process (Maxwell, 2008), because "interpretation begins with the first steps into the field" (LeCompte & Schensul, 1999, p. 147). Simultaneous data analysis and data collection helps the researcher to make informed decisions, such as how to evaluate the emerging concepts, themes, categories of data and how to refine the investigation process. For example, Ezzy (2002) asserted that simultaneous data collection and analysis "allows the analysis to be shaped by the participants in a more fundamental way than if analysis is left until after the data collection has been finished" (p. 61). Before undertaking the full investigation, the researcher first piloted the research instrument to identify the patterns in the data from an interviewee. The researcher used the first interview session as a guide for refining the interview questions. The cases in the case study generated qualitative data from licensed science teachers, headmasters, ward and district education officers and students through interviews, focus group discussion, documentary review, classroom observations and PDI. According to Cohen et al. (2011) there is no single or best way to analyse or present qualitative data—the choice of qualitative data analysis depends on "fitness of purpose" (p. 537) in relation to the research questions. Yin (2009) commented that straightforward strategies for analysing case studies data are not well established and data analysis is the most difficult task for the interpretive researcher. However, there are number of analytical techniques discussed in the literature that are commonly used in analysing qualitative data. These techniques include: grounded theory, content analysis, narrative analysis and thematic analysis (Bryman, 2008; Ezzy, 2002; Patton, 2002).

For the purpose of this study, thematic analysis was adopted as the approach for analysing data from the case studies. Thematic analysis is a "method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). A theme is defined as a specific pattern conveying a similar meaning that is found in the data which is of potential interest to the researcher (Guest, MacQueen, & Namey, 2010; Holloway, 1997; Yardley & Joffe, 2004). The thematic analysis approach is widely used in analysing qualitative data generated from interviews, field notes, documents, photographs, video recordings and participant observations (Boyatzis, 1998; Fereday & Muir-Cochrane, 2006; Taylor-Powell & Renner, 2003; Yardley & Joffe, 2004). This form of analysis was employed in this study because it is data driven and themes were developed from participants' interviews and classroom observations consistent with an interpretive paradigm (Ezzy, 2002). The analysis also used data-driven inductive (Boyatzis, 1998; Guest & McLellan, 2003), and deductive approaches (Fereday & Muir-Cochrane, 2006) in identifying and coding of the study themes. In the inductive approach themes are drawn by the researcher from raw data (Boyatzis, 1998; Braun & Clarke, 2006; S. Brown & Locke, 2008; Fereday & Muir-Cochrane, 2006), while the deductive coding/theoretical coding approach draws themes from existing theoretical ideas or frameworks that the researcher brings to the data (Boyatzis, 1998; Braun & Clarke, 2006; Guest et al., 2010).

Thematic analysis allows the researcher to organize the emerging themes into two groupings: those made at the manifest level and those at interpretive level (Braun & Clarke, 2006). The manifest level refers to directly observable themes from the raw data as reported by the research participants. In contrast, the interpretive level themes are indirectly observable and interpreted by the researcher from data by examining the underlying ideas and assumption (Boyatzis, 1998; Braun & Clarke, 2006; Yardley & Joffe, 2004). Boyatzis (1998) asserts that the thematic analysis approach allows the researcher to "use a wide variety of information in a systematic manner that increases their accuracy or sensitivity in understanding and interpreting observation about people, events, situation and organization" (p. 5). In addition, it allows constant cross-comparison of data from different case studies to enhance the trustworthiness of the findings (Thorne, 2000). However, Braun and Clarke (2006) caution that good thematic analysis usually utilizes both inductive and deductive approaches to identify themes and "focuses exclusively or primarily on one level" (p. 84) of theme identification. This study employed both inductive and deductive approaches in identifying and categorizing the themes (Fereday & Muir-Cochrane, 2006), and themes were also exclusively identified at the manifest level as narrated by the research participants. According to Fereday and Muir-Cochrane (2006), the use of both inductive and deductive coding approaches complements the research questions by allowing the researcher's pre-existing beliefs to contribute to the process of deductive thematic analysis while also allowing themes to emerge directly from the data using the inductive coding approach.

This study adopted the steps of thematic analysis that were drawn from the literature in this area (Braun & Clarke, 2006; Guest et al., 2010; Miles & Huberman, 1994; Robson, 2002; Taylor-Powell & Renner, 2003). The first step involved the researcher becoming familiar with the data by transcribing raw data, reading, and re-reading the data, and summarizing initial ideas (Braun & Clarke, 2006). Taylor-Powell and Renner (2003) argue that good qualitative data analysis depends on how the researcher understands his/her data. Knowing the data helps the researcher to understand the quality of his/her data. During data analysis for this study, the researcher immersed himself in the raw data by transcribing each interview session, listening to the audio tapes, and reading and re-reading the transcribed text. Through this process the researcher was able to identify and ascertain the patterns of data and the themes emerging from the raw data.

In the second step, the researcher focused on analysing the data by re-evaluating the purpose of the study and looking at what the study intended to find out (Taylor-Powell & Renner, 2003). Taylor-Powell and Renner (2003) and Cohen et al. (2011) suggested the two best options for focusing on the data analysis are: placing the focus on the research questions or topics, where the researcher organizes the data by research questions; and on a case basis, where data is organized according to an individual case or cases. In this study, the researcher repeatedly returned to transcribed text and organized the responses from each participant in each case study according to each interview and focus group discussion question. Taylor-Powell and Renner (2003) reported that the process of focusing on analysing data in relation to the research questions and case studies helps to "identify consistencies and differences" (p. 2) in each question and each case study responses. In the third step, the researcher created initial codes and giving them to the interesting features of the data in a systematic manner across the entire data corpus (Braun & Clarke, 2006; Miles & Huberman, 1994). The process of identifying and affixing initial codes is considered time consuming and labour-intensive because it involves reading and re-reading the transcribed text and then pulling out the pertinent themes (Taylor-Powell & Renner, 2003). At the initial coding stage of affixing codes the researcher usually starts by categorising directly observable themes from the raw data followed by the emerging themes (Miles & Huberman, 1994; Taylor-Powell & Renner, 2003). In this study the researcher started by coding directly observable themes or data-driven themes based on the research questions, and then followed with the emerging themes. Theme coding was an iterative process that resulted in a number of changes to earlier themes to match the research questions and purpose of the study.

The fourth step involved the researcher in conducting theme searching in order to refocus on the analysis at the broader level of themes (Braun & Clarke, 2006). These intensive searches were conducted across the initially coded themes, which were re-sorted under the overarching themes of the study. This process helped the researcher to identify supporting extracts during report writing. The researcher developed relationships between different themes, codes and levels of themes from the main themes ready for data analysis. For this study the researcher used tables to categorise themes and merge similar or related categories to form the main themes that were relevant to the research questions.

The fifth step in thematic analysis approach is reviewing and refining the themes (Braun & Clarke, 2006). The researcher re-read all the selected extracts to see if they made a coherent pattern, and to look at the validity of the themes in relation to the research questions. During this stage the researcher re-evaluated the overarching themes, whereby some themes were dropped because of the lack of enough data to support them, and others were broken down to form new themes. In this study the researcher re-evaluated the coded themes and summarized the themes that were supported by enough evidence from the data.

The sixth step in analysing data using the thematic method involved defining and naming the themes. According to Braun and Clarke (2006), at this stage the researcher selects the well-focused themes that capture the essence of the study and research questions. The process of naming, defining and refining the themes helped the researcher to select clear and concise titles for use in report writing. The final step is report writing and interpretation of the findings (Braun & Clarke, 2006; Taylor-Powell & Renner, 2003). At this stage the researcher lists the key findings discovered during the categorization of data and theme sorting, and involves the selection of important quotes from the participants. In this study the researcher reported the findings using key themes that were related to the research questions. The key themes were supported by extracts from the participant interviews, focus group discussion, reflection notes and classroom artefacts.

3.9 Research ethics consideration

Consideration of ethics is an important issue in any research that involves human beings as the subject of the study. Scott (1996) argued that interpretive research data collection is a social activity, whereby researchers in the field are faced with many methodological dilemmas. These fieldwork dilemmas require the researcher to make informed decisions, in particular, how s/he has to conduct the investigation, and what are the rights of the researcher and researched. The major ethical concerns in any social research that involves human beings relate to the potential harm to the research participants, participants' informed consent, privacy/confidentially and deception (Behi & Nolan, 1995; Bryman, 2008; Cohen et al., 2011; Diener & Crandall, 1978). Issues surrounding these ethical concerns are discussed in brief in the next sections.

3.9.1 Harm to the participants

According to Bryman (2008) and Diener and Crandall (1978), harm to research participants can take different forms. Harm can be physical and psychological, and can include hurting or inflicting pain, inducing stress in participants, forcing participants to perform culpable acts, lowering participants' self-esteem, and loss of trust between the researcher and participants. Any research that causes harm to its participants is considered unethical and unacceptable. It is the role of the researcher to ensure that s/he does not cause harm of any form to the study participants. In this study, the participants were protected from both physical and psychological harm, because the researcher maintained the confidentiality of individual classroom observations; participants were treated with respect and were not coerced; and participants' informed consent was obtained before involving them in the study or accessing their classrooms.

3.9.2 Informed consent

Informed consent is defined as "the procedure in which individuals choose whether [or not] to participate in an investigation after being informed of facts that would be likely to influence their decision" (Diener & Crandall, 1978, p. 34). It is the role of the researcher before involving his/her participants in the study to seek their informed consent. Diener and Crandall (1978) argued that "informed consent is absolutely essential whenever subjects are exposed to substantial risks or are asked to forfeit personal rights" (p. 34). Informed consent consists of four key elements: competence, voluntarism, full information and comprehension (Cohen et al., 2011; Diener & Crandall, 1978). The proponents of informed consent profoundly emphasize participants' freedom of choice and a coercion free research environment. The literature suggests that if participants are aware of their rights they take more responsibility for protecting themselves from harm (Bryman, 2008; Creswell, 2009; Diener & Crandall, 1978).

Bryman (2008) suggested that before involving participants the researcher should provide his/her subjects with the informed consent forms, which they should sign to indicate their willingness to participate. In addition, Creswell (2009) suggested that before accessing participants, the researcher should get official permission from the authorities by writing a letter of request describing the purpose of the research, the likely impact of the research, and the time commitment. This study was conducted in accordance with the University of Waikato Human Research Ethics Regulation 2008 and the New Zealand Association for Research in Education. Also, the researcher sought a research permit from the Ministry of Education and Vocational Training in Tanzania and submitted the permit personally to the district education offices and the heads of schools (see Appendices 1-5). The district and ward education officers were also given an invitation letter to seek voluntary participation in the study.

The headmasters of the schools were asked first verbally and then were given formal letters requesting access to teachers in their schools. Likewise, those teachers who showed willingness to participate in the study were given an invitation letter, and participation was voluntary. Each participant was asked to sign an informed consent form (see Appendix 8) prior to the commencement of the study. Each participant was given an information sheet (Appendix 19) explaining the purpose of the study, the rights of the participants, an outline of the interview guide, the focus group discussion guide; and two copies of informed consent form (one for them to keep and one for researcher). The participants were also given researcher contact details as well as those of the project supervisors. The researcher asked permission from the subject teachers to access their classrooms for lesson observations. None of the participants was coerced.

3.9.3 Protecting participants' privacy/confidentiality

Privacy is a basic right of the research participants and should not be jeopardised during the research process (Bryman, 2008; Cohen et al., 2007; Denscombe, 2010). Diener and Crandall (1978) commented that "privacy is a value that must be carefully considered when planning research, because the goals of social scientists will often conflict with this right" (p. 54). There are basic dimensions of privacy that need consideration during the research. These dimensions are: sensitivity of the information given by the participants; the study setting being observed; and dissemination of the findings (Cohen et al., 2007; Diener & Crandall, 1978). The sensitivity of information refers "to how personal or potentially threatening information is [sic] that is being collected by the researcher" (Cohen et al., 2007, p. 63). This dimension of privacy means that the researcher should take great care when reporting sensitive data that may have impact on the privacy of the study participants or a school. It is the duty of the researcher to maintain the privacy of the study setting if the study will result in sensitive information being disseminated that will likely damage the image of the institution under study. In this study, the confidentiality and anonymity of every participant was of the utmost importance. In order to ensure complete anonymity of all participants, the following steps were taken: first, the raw data was not accessed by anyone else except the researcher and supervisors; second, the data was not used for any other purpose other than this study; and last, the identity of the participants was kept anonymous, and data analysis and report writing used pseudonyms. The data was kept in a securely locked cupboard during the research process and afterwards.

3.9.4 Deception

Deception is "a psychological process by which one individual deliberately attempts to convince another person to accept as true what the liar knows to be false, typically for the liar, or sometimes for others, to gain some type of benefit or to avoid loss" (Abe, 2011, p. 560). However, in social research deception means purposeful distortion of the scientific inquiry to subjects of the study for the purpose of gathering information from the research participants. According to Diener and Crandall (1978) and Lawson (2001), social researchers can practise the following forms of deception: first, deception done by commission, where the researcher directly lies to his subjects; second, deception by omission of information, where the researcher deliberately misleads or misinforms his participants; and third, the purpose of the study is not elucidated to the participants and what will happen is not explained to the participants. In this study, the researcher discussed with participants the purpose of the study and the implication of their participation. All the information was kept open to the participants and no rights of any participant were infringed during the study.

3.10 The theoretical basis of teachers' learning in professional development

This study assumes that teachers' knowing and learning are "situated in physical and social contexts, social in nature, and distributed across persons" (Putnam & Borko, 2000, p. 12), and the construction of knowledge occurs through active participation or engagement of learners in a social learning community (Richardson, 2003). Thus, teachers' knowing and learning are influenced by the context, and knowledge is found in their daily working environment and is acquired through active participation in social activity (Daley, 2000, 2001; Vescio et al., 2008). The potential that the daily working environment has as regards teachers' learning was also emphasized in the work of Melville (2010). He argued that "the work of teachers is so heavily contextualised, it is necessary to consider the various elements that constitute the context of their work, and the impact of those elements on professional learning" (Melville, 2010, p. 44). This study adopted the view that teachers' learning is situational, knowledge is socially constructed, and that teachers learn well when they work together as a community of learners in their school local context (Owen, 2004; Putnam & Borko, 2000), on the assumption that learning “is a social activity that is enhanced by shared inquiry” (Daley, 2001, p. 40). The view that teachers’ knowing and learning is situational is influenced by the context and social engagement in a community of practice, which are the tenets of the situativity theory. Therefore, this study adopted the situativity theory as the theoretical basis for informing teachers’ professional development intervention (Pella, 2011; Richardson, 2003).The situativity theory “emphasises learning as being connected to the situation, with individual cognition and meaning being socially and culturally constructed” (Owen, 2004, p. 4). Teachers construct their own knowledge through social engagement (Lave & Wenger, 1991), and construction of knowledge is the result of active participation in social discourse as a community of practice (Greeno, 1997; Henze, Van Driel, & Verloop, 2009). Others have argued that the situativity theory is a powerful lens for studying teachers’ professional learning (Barab & Duffy, 2000; Owen, 2004; Pella, 2011; Putnam & Borko, 2000) because it values school-based teacher learning, which provide teachers with opportunities to practise and share their the new skills they have learnt (Duncombe & Armour, 2004). There is an immense body of literature (e.g., Borko, 2004; Borko & Koellner, 2008; Daley, 2001; Owen, 2004; Pella, 2011; Putnam & Borko, 2000) reporting that when teachers’ professional development is aligned to the tenets of the situativity theory it has as positive impact on teachers’ subject content knowledge, their classroom instructional practices and student achievement.

Other studies suggest that teachers’ learning activities are influenced by the physical and social environment of their learners (Barab & Duffy, 2000; Borko & Koellner, 2008; Henze et al., 2009). For example, Peressini, Borko, Romagnano, Knuth, and Willis (2004) commented that if we are to “understand teacher learning, we must study it within these multiple contexts, taking into account both the individual teacher-learners and the physical and social systems in which they are participants” (p. 69) as a community of learners. From this perspective teachers’ learning “takes place within the practices of the community” (Schuh & Barab, 2008, p. 75), and the social learning world is developed as a result of teachers’ practices within a community of learners (Lave & Wenger, 1991). As

Borko and Koellner (2008) pointed out, from the situativity perspective, a "critical aspect of professional development is the development of [teachers] community" (p. 2). Thus, a PDI aligned with the context of community participation allows collective learning and negotiations of knowledge (Borko & Koellner, 2008) and it supports cross-group learning and the creation of teacher networks (Higgins & Parsons, 2009). Higgins and Parsons (2009) claimed that an effective teachers' PDI should be situated in the context of the practice of the teachers'. Therefore, the situativity theory was considered helpful in examining teachers' PDI in the context of their school environment.

3.11 Summary of the chapter

This chapter presented the research methodology. The study adopted qualitative research methods within the interpretivisim paradigm and the case study design was used to explore the research problem. The study adopted the non-probability sampling approach and participants were selected using the purposive sampling technique. The data was collected using interviews, observation, focus group discussion and documentary analysis. Trustworthiness issues based on qualitative research criteria were also discussed and ethical considerations adopted by the study were also presented in detail. Thus, the study adopted the situativity theory as a theoretical framework for teachers' learning during the PDI, which suggests that teachers' knowing, learning and construction of knowledge are situational and influenced by the social context that involves the individual teacher in sharing skills and knowledge with peers as a community of practice. The next chapter presents the findings from six licensed science teachers and education officers in the first phase of the study.

CHAPTER 4: PHASE ONE
FINDINGS OF THE LICENSED TEACHERS' PCK NEEDS

4.1 Introduction

This chapter presents the findings from the first phase of the study concerning licensed teachers' professional learning needs and the effectiveness of their use of learner-centred instruction. These findings from the first phase also revealed the strengths and weaknesses of existing teachers' professional development programmes for supporting licensed science teachers, and the factors supporting the establishment of teachers' professional learning communities (PLCs) in Tanzanian community secondary schools.

4.2 Licensed science teachers' PCK training needs

This section reports the findings obtained from one-to-one interviews (see Appendix 11) with six licensed science teachers, a follow-up focus group discussion (See Appendix 16) with all six of the licensed science teachers, and information collected from analysis of their teaching documents (teachers' schemes of work and lesson plans, students' classroom tests and examinations) which they had prepared. These instruments were used to identify the licensed science teachers' professional learning needs, in particular, those related to PCK. The majority of the themes that emerged from the collected data revolved around the components of PCK identified by Magnusson et al. (1999). The themes that emerged from the collected data were organized into five main themes of Magnusson PCK framework. These are: (i) licensed science teachers' beliefs about and orientation to science teaching (ii) licensed science teachers' knowledge of the science curriculum (iii) licensed science teachers' knowledge of science learners (iv) knowledge of instructional strategies and (v) knowledge of science assessment. The sixth theme that emerged from the data concerned the licensed science teachers' perceived mode of meeting their professional learning needs. These themes of licensed science teachers' PCK needs are reported in the next section.

4.2.1 Licensed science teachers' beliefs about teaching science

The first theme that emerged from the data relating to PCK is licensed science teachers' beliefs about science teaching. The licensed science teachers believed that the effective teaching of science was influenced by the availability of teaching and learning resources in the school environment. They advocated that teaching science through experiments and practicals enhances students' understanding. Yet typically they reported their schools lacked the necessary resources for such teaching.

> Yeah, as you know biology and chemistry are science subjects that require a teacher to teach them using practicals, but at this school I am teaching my subjects theoretically because there is no science laboratory for conducting science practicals…. in order for students to understand the topics, it requires the science teacher to do some experiments or to demonstrate what he is teaching so that students can understand the subject. …teaching topics such as 'gaseous exchange' and 'respiration' in my school is difficult as we don't have laboratory apparatus to demonstrate the mechanism of respiration and excretion. These topics are abstract and to teach them you need scientific apparatus. (Qwary, phase 1 interview 1)

Tiita said that "it is difficult for me to teach topics like electronics and electromagnetism in the physics syllabus because they are abstract and there are no instruments to demonstrate these topics in the school (Tiita, phase 1 interview 6). Another teacher had this to say about inadequate laboratory supplies in the school:

> … in the school biology laboratory we don't have important chemicals for doing practicals, and as you know biology teaching requires both the use of theory and practicals to aid students' understanding…science teaching requires students to use their senses such as touching, smelling, tasting, observing and hearing. (Pombe, phase 1 interview 2)

The teachers felt that having a laboratory plays a key role in the teaching of science subjects as it enables students to understand and learn them more effectively. Given the inadequate supply of teaching materials and laboratory materials, the licensed science teachers believed that the lecture method is the next best approach for teaching students. Tiita illustrates how a lack of teaching materials and the skills to prepare them led him to choose a lecture style delivery.

> I frequently use the lecture method in my classes because it is easier to use when teaching large classes. ...another challenge is how to prepare teaching and learning materials, because this was not taught in the induction course… and teaching materials are not available in the school. (Tiita, phase 1 interview 6)

The second theme to emerge from the data concerning licensed science teachers' professional learning needs was the need to enhance licensed teachers' knowledge of the science curriculum, which is discussed in the next section.

4.2.2 Licensed science teachers' science curriculum knowledge

This section reports on licensed science teachers' knowledge of the science curriculum content as perceived PCK needs by the teachers themselves and education officials during the interviews and focus groups discussion.

4.2.2.1 Inadequate understanding of science content

The findings from interviews and focus group discussions with licensed science teachers and education officials indicated that these teachers felt that they lacked knowledge of the science curriculum, in particular its science content as well as the skills for teaching some science topics. The teachers acknowledged that they had inadequate knowledge for understanding and teaching some science topics. Qwary confirmed that "licensed teachers need training in how to teach their subjects, in particular their content. Here I mean that training should focus on the specific subjects we teach in school, such as biology, physics and chemistry"

(Qwary, phase 1 interview 1). Similar views were also expressed by Tiita and Pombe.

> It is difficult for me to describe specific training needs, but I think that revising how to teach the subjects and conduct science practicals are more important training needs at the moment…. we are not trained in how to prepare practical lessons in the induction course and there is no help here at the school…I do not have the skills for conducting science practicals. (Tiita, phase 1 interview 6)

> In my opinion I need to be taught how to prepare and teach practical lessons because this was not covered during the induction course… the training should include specific subjects, such as chemistry, biology, physics and mathematics, which are the subjects we teach in secondary schools. (Pombe, phase 1 interview 2)

Tiita's and Pombe's views suggest that the licensed science teachers have inadequate science curriculum knowledge and hence PCK, in particular about how to prepare and teach science practicals. The licensed science teachers' perception that they lack the ability to teach practical lessons is a result of the inadequate coverage of the science curriculum content in the four-week induction course conducted by MoEVT because the course aimed to provide licensed teachers with the basics of classroom teaching. This study also triangulated the sources of data to crosscheck the credibility of the views of licensed science teachers by talking to their immediate supervisors, such as headmasters, district education officers, ward education officers and school inspectors. When the education officials were asked their impressions of licensed science teachers' content knowledge and the teaching of practical work, they expressed similar views.

> Licensed teachers do not have the skills for preparing practical lessons, which I think is one of their training needs... they lack practical teaching

> skills because most of them studied an 'alternative to practicals'[3] in ordinary secondary levels. Also, in Form 6 they did practicals as students simply to pass the final national examination. (Headmaster, Tlawi secondary school phase 1 interview 8)

The headmasters also explained that most licensed science teachers are high school leavers with poor examination results, and that they lack understanding of the subject content matter.

> Licensed teachers do not have adequate content knowledge because they are high school students who scored lower marks in the final national examination…these weak students were left behind after the best students were selected to join universities. Therefore, because they don't really understand the content of specific subjects, many of them are unable to teach the content of their specific subjects. (Headmaster, Hewasi secondary school phase 1 interview 7)

Another headmaster concurs:

> You know, most of the licensed teachers are stranded [without anywhere to go after low achievement in high school examination results] high school leavers, who poorly performed in the national examination, and so when this opportunity came up they all applied for it… many of the applicants received a marginal pass in their teaching subjects, such as physics, chemistry and mathematics. (Headmaster, Tlawi secondary school phase 1 interview 8)

The District Education Officers also identified the lack of content knowledge as an issue and recognized the need to enhance licensed science teachers' subject content knowledge.

---

[3] Alternative to practicals' is an alternative mode of teaching science practicals, whereby students memorize the science experiments theoretically and then do the examination on the basis of the experiments memorized in schools with an inadequate supply of laboratory equipment and consumables for carrying out real or wet practicals.

> Licensed science teachers should get a dose [of training] in mathematics or physics first, and then extra training in teaching methodology should be given to them, because if the teacher does not understand the content of physics or mathematics, even though he [she] knows how to teach mathematics or physics, he [she] will be teaching something that merely resembles mathematics or physics. For example, in order for a teacher to solve a physics question, he [she] must first understand the physics content and then the method for solving the question. In my view teachers should master first the content of the subject and then the methodology for teaching it. (District Education Officer I, phase 1 interview 9)

When expressing similar sentiments another District Education Officer also reported that some licensed science teachers have difficulties understanding students' textbooks and preparing their teaching notes.

> Licensed teachers do not have a good understanding of the content of subjects they are teaching … some licensed teachers were found using their old notes for teaching students, which shows that some of them lack skills for constructing teaching notes from the textbooks…. even understanding students' science textbooks is a problem for some licensed teachers. (District Education Officer II, phase 1 interview 10)

Interestingly, this claim made about licensed teachers' behaviour of using their 'old notes' from ordinary secondary school as teaching notes for their students was also confirmed by Tiita during the pre-intervention focus group discussion. He commented:

> On the poor teaching of science subjects us teachers must take the blame because when we go into the classroom to teach we haven't thoroughly prepared our lesson, but go into the classroom with our old notes… You just take your books or old notes, what I call 'yellow notes', you start delivering your lesson, you face the blackboard and you talk to the blackboard instead of the students and whether students have understood the lesson or not is not my business. (Tiita, phase 1 Focus group discussion)

Apart from using their old school notes the licensed teachers were also reported using textbooks as teaching notes by directly copying from the books instead of extracting teaching notes from a variety of different sources.

> In my inspection work I have found some licensed teachers using textbooks as teaching notes rather than extracting guiding notes from different textbooks, and they copy directly from one source without constructing notes from different textbooks and reference books…. (Regional School Inspector, phase 1 interview 11)

Classroom observations of licensed teachers' classroom practices corroborated these views, as many teachers used textbooks as their teaching notes with some copying a lesson summary for their students on the blackboard directly from the textbooks (see Appendix 20 lesson narratives). These views from a range of participants indicate that the licensed science teachers have inadequate understanding of the science curriculum content, that is, their subject content matter. The education officers, headmasters and regional school inspector reported that some teachers were even unable to construct teaching notes for students. Therefore, these findings suggest that licensed science teachers need professional learning support to enhance the curriculum content component of their PCK.

4.2.2.2 Challenges of teaching new topics in the science curriculum

The licensed science teachers also reported that the science syllabus contained some topics that were new to them and they felt that they were not knowledgeable enough to teach some of these topics.

> Of course, some topics recently introduced in the biology syllabus are difficult to teach. For example, I have a problem teaching the topic called 'balance of nature', because I didn't learn it in high school. (Safari, phase 1 interview 3)

> You know government decisions are sometimes interesting; they have introduced new topics in the new syllabus without teaching teachers first,

> for example, the topic of accounting in the new mathematics syllabus. I usually skip teaching this topic every year because I never studied it in high school and I don’t have knowledge of accounts. (Manimo, phase 1 interview 4)

> Some topics are difficult to teach, for example, those you were not taught or didn’t understand when you are in ordinary level secondary school or high school, and so, when you come across these topics, instead of teaching them you skip them, for example, the topic of the lymphatic system in biology. (Sungura, phase 1 interview 5)

These teachers’ views appear to confirm that licensed teachers depend largely on their limited science knowledge gained from their own junior secondary and high school schooling to teach science in their schools. The licensed teachers also acknowledged the presence of abstract topics that they consider difficult to teach.

> For example, things like electrons or atoms in physics cannot be seen by the naked eye, and so all you can do as a teacher is to build the confidence of students to learn abstract things by telling them that these things exist, and you will see them in the future when you get a chance of further studies at university. (Sungura, phase 1 Focus group discussion)

> Topic like genetics is difficult to teach and for students to understand, and to teach this topic you need to do extra work because the topic is abstract. (Safari, phase 1 interview 3)

These comments indicated that some topics in the science syllabus were inadequately covered during classroom instruction as teachers reported skipping new topics in the syllabus. All the participant teachers were observed (see Appendix 20) having difficulties in teaching in particular their subject content such as physics, chemistry, and biology, in particular giving relevant examples to help students’ understanding of the subjects. Teachers were observed giving examples only from the science textbooks or their old science notes not from other sources. Their comments suggest that to teach some of the new topics or abstract topics their subject content needs to be enhanced in these areas. The third theme that emerged from the data concerned PCK training needs is reported in the next section

4.3 Licensed science teachers' 'pedagogical knowledge' training needs

This section reports on the perceived pedagogical knowledge training needs that licensed science teachers felt need to be addressed in order to teach science effectively. In the context of this study and to Tanzanian licensed science teachers pedagogical knowledge means 'teaching methodology'. The licensed science teachers used the term 'teaching methodology' when referring or how to teach. They stated that they need training in teaching methodology. During the interviews, the licensed science teachers raised a number of issues relating to their pedagogical knowledge learning needs or teaching methodology, in particular, challenges concerning classroom management, understanding students with different learning needs and lesson preparation skills. These lists of teaching methodology needs fall within the PCK components of knowledge of learners and their characteristics, knowledge of instructional strategies and knowledge of science assessment, and each of these are discussed in the next sections.

4.3.1 Knowledge of learners and their characteristics

The findings from interviews with licensed science teachers indicated that these teachers felt that they need professional learning support to teach their students. This perception is illustrated in the comments made by Manimo:

> Licensed teachers need training in teaching methodology and how to help students to learn. Of course, when I was employed I was very young and so students have little trust in many of us because we are nearly the same age as them. You know at that time, I had few skills for managing students in the classroom. (Manimo, phase 1 interview 4)

In a similar vein, Tiita reported that parents and the community at large see licensed teachers more in a caretaking role rather than teaching.

> You know parents consider licensed science teacher as a student employed to teach their fellow students in order to keep students doing something rather than them remaining idle in the classroom. (Tiita, phase 1 interview 6)

Two teachers reported that induction was inadequate and did not cover how identify and teach students with special needs. These claims are summarised in the following statements:

> To some extent the induction course covered some concepts such as methods of teaching but not all methodology concepts or techniques of teaching were covered due to the short time allocated to the induction course… professional development should focus on teaching methodology, for example, how to recognizing talented and untalented students in the classroom and how to develop students' talents. (Manimo, phase 1 interview 4)

> You know during the induction course I did not acquire enough teaching skills because there was no time to practise how to teach. For instance, how to apply the psychology of learning and participatory teaching methods, and how to identify and help students with special learning difficulties was not covered in the course. (Tiita, phase 1 interview 6)

These licensed science teachers' views illustrate that they felt a need for professional development to help them understand how students with different learning difficulties learn and how to recognise students with special learning needs. The licensed science teachers recognized that their pedagogical skills were underdeveloped and needed to be enhanced through further professional development.

4.3.2 Teachers' instructional teaching artefacts

The teaching artefacts referred to in this study include teachers tests and examinations, teachers' schemes of work and lesson plans. Teachers in Tanzania are provided with pre-designed templates for lesson plans and scheme of work to simplify their work so they can more easily prepare their teaching artefacts. Each licensed science teacher was provided with a scheme of work and lesson plan in a ready-made template with various sections to fill in. However, examination of these templates indicated that their content varied from one school to another. The licensed science teachers expressed uncertainity around the planning of instructional artefacts, particularly about filling in some sections of work schemes and lesson plans. The examination of licensed science teachers' schemes of work indicated gaps in their planning. For example, some sections of schemes of work were not completed and some of the filled in sections contained non-aligned information such as the sections on reflection, assessment, student evaluation and teacher's evaluation. It was also found that of the six licensed science teachers observed in this study, Tiita was only one who was using a lesson plan in his classroom. The licensed science teachers said that they did not prepare and use lesson plans because they had too many classes to teach each day. Pombe explained that "there is no time to prepare even a lesson plan as I am teaching many hours a week because there are few science teachers in my school" (Pombe, phase 1 interview 2). The Tlawi secondary school Headmaster highlighted the difficulties associated with the checking of planning by the licensed teachers

> … it is difficult for the office to do serious follow up of lesson plans because these teachers teach many hours and some are employed temporarily… and if you put more pressure on them they will turn down teaching and we [will] have [a] shortage of teachers. (Headmaster, Tlawi secondary school phase 1 interview 8)

Detailed analysis of the licensed science teachers' schemes of work showed that they were facing a number of challenges filling in certain sections like assessment, lesson competencies, lesson objectives and remarks section (teachers' schemes of work documents). For example, the teachers seemed unable to translate reflection questions given in the assessment section into students' assessment activities, while some could not differentiate between lesson objectives and lesson competencies. For example, Pombe in her scheme of work was unable to distinguish between lesson competence and lesson objective(s) (see italicised text in the extracts given). Also, her student assessment activities were unclear, because she did not describe explicitly what assessment methods she was going to use to evaluate students' learning outcomes.

> Subject: Biology
> Lesson competence: *student to explain general and distinctive* features of Agiospermophyta.
> Lesson objectives: *student to be able to explain distinctive* features of Angiospermophyta.
> Assessment: *Is student able to explain the general and distinctive* features of Angiospermophyata? (Extract taken from Pombe's biology lesson scheme of work, phase 1)

Safari's scheme of work lacked the components that a competence-based lesson should contain namely behaviour, skills and knowledge. Likewise, it was found that some lesson objective(s) lacked essential elements of a well stated lesson objective, namely the audience, behaviour to be changed, the situation in which the behaviour will be demonstrated and the degree of performance.

> Subject: Chemistry
> Lesson competence: *working safely* in the laboratory
> Lesson objective(s): *carrying out chemistry* activities in a safe way
> Assessment: *now student can explain [the] meaning [of the] roles and precaution[s]* to take in the laboratory. (Extract taken from Safari's chemistry lesson scheme of work, phase 1)

In another example, in some sections of Qwary's scheme of work, lesson competence did not relate to the lesson objective(s).

> Subject: Chemistry

Lesson competence: *the student to gain prior knowledge and skills of* chemistry laboratory
Lesson objective(s): the student to explain the layout of chemistry laboratory and procedure for making ugali
Assessment: *the student[s] were able to explain [the] meaning* of laboratory. (Extract taken from Qwary, chemistry lesson scheme of work, phase 1)

Likewise, in Sungura's scheme of work some sections of lesson competence were not filled in. He appeared unable to develop student activities for assessing the lesson but instead he mistakenly answered the reflection question suggested in the assessment section of the science syllabus.

Subject: Physics
Lesson competence: *not filled in*
Lesson objective(s): the student should be able to explain the concept of astronomy
Assessment: *the student[s] were able to explain the concept of astronomy*. (Sungura, Extract taken from physics lesson scheme of work, phase 1)

These schemes of work examined indicated the challenges facing licensed science teachers in preparing teaching artefacts.

4.3.3 Teachers' knowledge of assessing and evaluating students learning

The licensed science teachers during the focus group discussion reported that they were uncertain about what to fill in and who should fill in the sections on teacher evaluation, student evaluation, and assessment in their lesson plan templates. Here Tiita describes his difficulties with the terminology used in these documents during the first phase focus group discussion.

Sorry sir, what is assessment? Because this is confused with evaluation, what is the difference between assessment and evaluation…in our new

> lesson plan template they have introduced sections for teacher evaluation and reflection, and in the scheme of work template there is also an assessment section. Can you explain each concept before we carry on to our discussion…I get confused over the use of these terms in the lesson plan. (Tiita, phase 1 focus group discussion)

Instead of responding to Tiita's question, the researcher asked the focus group discussion participants to respond specifically to Tiita's concerns from their own experience. The participants were quiet for nearly two minutes and no participant responded to Tiita's request. Finally, Manimo decided to break the silence by raising a similar concern.

> Look at my scheme of work, I failed to fill in the assessment section, is it 'evaluation'… will you help me today to understand what should be written in the assessment section in the scheme of work?...If you read the syllabus guide, questions are written in the assessment section which are not clear. (Manimo, phase 1 focus group discussion)

Some licensed science teachers reported that students should be given the opportunity to evaluate their teachers while others disagreed. The discussion was vigorous as licensed science teachers debated what should be filled in the sections for student and teacher evaluation in the lesson plans. Here are some of their views:

> There are sections in the lesson plan for student and teacher evaluation, which is confusing because who is meant to evaluate the teacher? For example, does the teacher evaluation section mean that students will be evaluating you when you are teaching or do you write your own evaluation? This section is not clear to many teachers. (Sungura, phase 1 focus group discussion)

> The way I understand it is that teacher evaluation means that after you have finished teaching you call a student and ask him if the lesson was understood, what were the difficult areas during the lesson, and which areas

> need to be repeated in the next lesson ... yes I think that evaluation. (Pombe, phase 1 focus group discussion)

Sungura's views suggest that the teachers did not know how to do self-evaluation, that is, before, during and after the lesson or reflect on their own practice. Pombe thought it was the students who evaluated teachers' classroom practice, which occurred when the teacher asked a few students to give their views on the lesson at the end. In contrast, Manimo and Qwary thought students should not be allowed to evaluate them.

> No! No! The teacher to be evaluated by his students! I think that is one of the challenges of participatory teaching methods; it means that students are also evaluating you, I mean students evaluating their teachers, you will not like that… I certainly wouldn't like to be evaluated by my students…after all students do not have enough knowledge to evaluate their teachers. (Manimo, phase 1 focus group discussion)

> …I think our students will abuse this section of evaluating their own teachers, they will write negative things about you because they don't like studying your subject or you have punished some of them for their bad behaviour and will use this section as an opportunity to retaliate. (Qwary, phase 1 focus group discussion)

Another participant added that "in the new lesson plan template there are sections for remarks, reflection, consolidation, reinforcement, teacher evaluation and student evaluation as well as assessment, which is very confusing, because consolidation and reinforcement look similar to me" (Pombe, phase 1 focus group discussion).

4.3.4 Analysing test and examination items using Bloom's categories of knowledge

This study used Bloom's taxonomy to analyse samples of students' tests and examinations prepared by the licensed science teachers from the case study schools. In order to ensure trustworthiness Blooms knowledge categories the researcher employed code-strategy method – where the researcher coded the same data twice by giving at least two weeks' gestation period between each coding of the analysis. The findings showed that most of the test and examination items were testing the lower levels of Bloom's categories of knowledge that is, knowledge, with some instances of items requiring application, comprehension and analysis abilities. None of the test and examination items was found to assess the synthesis and evaluation levels of Bloom's knowledge categories (Table 3).

Table 3: *Test items testing different levels of student knowledge by percentages*

Names of teachers'	subjects	Number of test items	Categories of knowledge levels tested by proportion (%)					
			Knowledge	compression	application	Analysis	synthesis	Evaluation
Pombe	Biology[4]	33	85	12	3	- [5]	-	-
	Biology[6]	40	80	3	7	10	-	-
Sungura	Biology[7]	30	76	-	24	-	-	-
	Physics[8]	21	73	3	24	-	-	-
Safari	Chemistry	67	57	12	23	8	-	-
	Physics[10]	48	88	-	12	-	-	-
Qwary	Chemist[11]	55	76	9	11	4	-	-
	Biology[12]	18	44	11	17	28	-	-
	Biology[13]	59	86	-	12	2	-	-
Manimo	Physics[14]	22	86	-	14	-	-	-
Tiita	Data was not applicable							

Source: Tests and examination past papers prepared by licensed science teachers

For example, the Form 3 terminal biology examination prepared by Pombe consisted of 33 items. Analysis of these items shows that 28 (85%) were testing

[4] Biology Form 3 terminal examination
[5] Dash means the items were missing in the test
[6] Biology Form 3 annual examination
[7] Biology Form 1 test
[8] Physics Form 3 annual examination
[9] Chemistry Form 4 mock examination
[10] Physics Form 2 pre-mock examination
[11] Chemistry Form 2 Pre-mock examination
[12] Biology Form 3 mid-term test
[13] Biology Form 1 terminal examination
[14] Physics Form 1 physics annual examination

knowledge, 4 (12%) were testing comprehension and 1 (3%) was testing application. A similar trend was seen in her annual biology examination with 32 (80%) items were testing knowledge, 4 (10%) items testing analysis, 3 (8%) were testing comprehension and 1(2%) testing application (Table 3).

In addition the headmaster from Tlawi secondary commented that most of these teachers rarely use the *table of specifications*[15] to construct their test items. He said:

> If you evaluate the types of test or examination questions prepared by licensed [science] teachers, you will immediately recognize that these questions have not been prepared by a qualified teacher. They are not following the principles of test construction like the use of a blueprint. Licensed teachers usually copy questions from textbooks and previous past papers without using the table of specifications. (Headmaster, Tlawi secondary school, phase 1 interview 8)

The licensed teachers in this study produced test and examination items that failed to assess students' higher order learning as measured using Bloom's knowledge categories.

4.3.5 Licensed science teachers' ability to construct test items

The results indicated that the licensed science teachers seem unable to construct quality test items, when they attempted to produce multiple choice, matching, true or false, fill-in-the-blank and essay type items. Most test items prepared by the licensed science teachers contained grammatical errors and spelling mistakes and some were not constructed according to agreed techniques and principles of test construction. For example, in some questions the stem of the test items was vague, or the manner in which the questions were to be answered was not provided, or it was difficult for students to understand. Other questions failed to test any scientific knowledge. Here are some examples of poorly constructed test items

[15] A table of specification is a blueprint made by a teacher during construction of tests items to ensure appropriate representation of test items across Bloom's cognitive objectives and avoid testing only the lower level of knowledge categories and address the test validity and reliability.

selected from various licensed science teachers' examination past papers to illustrate these statements:

> Question No. 1(iv). Organisms which can interbased [sic] and produced [sic] fertile offs prings [sic] are known as (a). Genus (b) Species (c) farmily [sic] (d) Class. (Sungura, phase 1 Biology Form one annual examination paper)

Question No. 1(iv) Sungura's test contains words with spelling errors such as 'interbased', 'offs prings' and 'farmily'.

> Question No. 1(ix). Annas [sic] mother always wear [sic] a very short skirt and tight light blouse. What is true about Anna's mother? (a) she is an example of [sic] parent with good manner [sic] (b) she is good for youth to imitate (c) She is a modern woman (d) She is bad model for her children and neighbours. (Sungura, phase 1 Biology Form one annual examination paper)

Likewise, question 1(ix) has two main errors, first in the name 'Annas' the apostrophe is missing as it should be written Anna's and second, the question does not test any scientific knowledge and also shows the personal bias of the teacher.

Erroneous constructions of the stem of multiple choice test items were found to be the main problem in most of the tests and examinations analysed. Some test items were hard to understand because the stems were grammatically incorrect; and sometimes the directions concerning the test items were unclear. Here are examples of test items illustrating the test stems that are grammatically incorrect.

> Question No. 11(a). Distinguish [sic] the analysed terminologies (i) pure water and impure water (ii) Hard water and soft water. (Qwary, phase 1 Chemistry Form 2 mock examination paper)

> Question No. 5(a). Two functions of micrometer screw gauge (i)........... (ii)........... (Safari, phase 1 Form 2 Physics mock examination paper).

> Question No. 2(b). List five diferents [sic] betweens [sic] non-metals and metals (physical properties). (Safari, phase 1 Form 4 Chemistry mock examination paper)

> Question No. 3(a): Why doesn't water have any effect on litmus paper? (Safari, phase 1 Form 3 Chemistry mid-term examination paper)

> Question No. 6. With balance [sic] write down the formula of the [sic] salt when heated. (i) Hydrated cupper [sic] II sulphate when heated. (Safari, phase 1 Form 3 chemistry mid-term examination paper)

In this question the wrong word was used.

> Question No. 10(a). Draw a well labelled diagram of map [sic] of the human tongue showing the taste buds. (Pombe, phase 1 Biology Form 3 terminal examination paper)

The word 'map' would not apply to the human tongue, and could be confusing for the students. The question would better read: 'Draw a well labelled diagram of the human tongue showing the taste buds'.

In the following example there is a grammatical error, as the word 'label' should be 'labelled', and the question is also gender insensitive because all human beings have the same structure of the elementary canal.

> Question No. 10. Draw a well label [sic] diagram of elementary canal of man. (Pombe, phase 1 Biology Form 3 annual examination paper)

These findings suggest a low level of English proficiency among licensed teachers with inappropriate use of vocabulary and grammatical difficulties.

4.4 Best approach for meeting licensed science teachers' professional learning needs

When the licensed teachers were asked to suggest the best approaches for meeting their professional learning needs, two sub-themes emerged from the data: the use of short workshops or seminars, and residential teacher education training programmes. These licensed teachers' perceptions of the best way of addressing their professional learning needs are reported in the next section.

4.4.1 The use of workshops and seminars

Of the six licensed science teachers involved in this study, four teachers and one headmaster suggested the use of workshops or seminars as the best strategy for meeting licensed teachers' professional learning needs. For example, Safari said:

> I think licensed science teachers could be effective teachers if the Government were to provide them with short training workshops or seminars. The workshops could be conducted between June and November, which is the long vacation period for teachers and students each year, which is when teachers would be free to attend. This would help these licensed science teachers to acquire professional teaching skills. (Safari, phase 1 interview 3)

Sungura had a similar view, commenting that "after reporting to school licensed science teachers should attend short seminars to help them learn more in areas such as teaching methods and the curriculum … licensed science teachers need frequent in-service training through workshops and seminars" (Sungura, phase 1 interview 5). Tiita also supported the idea of using seminars and workshops as a means of enhancing teachers' professional teaching skills. He said that "I believe that in-service training, such as seminars and workshops at least twice per year or more, would help licensed science teachers to be effective teachers in the classroom" (Tiita, phase 1 interview 6).

Some teachers revealed that they had requested the school management to give them an opportunity to attend workshops or seminars. During the interview Pombe said that: “I once asked the school management if there was any professional development workshop but the response was not positive because the school did not have enough funds” (Pombe, phase 1 interview 2). One school headmaster reiterated this view in the context of practical work. He said: “licensed science teachers need to attend seminars to help them learn how to prepare science practicals” (Headmaster, Tlawi secondary school phase 1 interview 8). These participants’ comments believed in short workshops as a viable means of addressing science teachers’ professional learning needs as well as being an opportunity for teachers to acquire new skills.

4.4.2 Attending residential teacher training

Other licensed science teachers and education officials considered a residential teacher training programme as an alternative approach to meeting licensed teachers’ professional learning needs. In their view the best approach would be for licensed science teachers to attend a full-time residential teacher education course offered in a teacher training college or university as the community secondary school environment did not support a distance learning approach for licensed teachers in their view. Manimo commented that:

> A good approach would be to advise licensed science teachers to join a residential training programme, such as a diploma in education, or a university course, because the community secondary school environment does not support the distance learning approach recommended by the Ministry of Education for licensed science teachers because at the university or diploma college you will study smoothly due to availability resources and you will finish on time. (Manimo, phase 1 interview 4)

Likewise, a headmaster also commented that “the Government should enable licensed teachers to attend residential courses at teacher education training institutions to get real training in teacher education” (Headmaster, Hewasi secondary phase 1 interview 7). District and Ward Education officers were more in favour of residential teacher education programmes than short training courses such as workshops and seminars. A ward education officer said "I would advise the Government to arrange a training programme to allow them to attend a two-year residential diploma course to improve their classroom practice. I think short courses would have little impact" (Ward Education Officer, phase 1 interview 12). The district education officer has actually encouraged licensed teachers to apply for a two-year residential diploma course. He commented that:

> When I reported to this district, what I did first was to mobilize the licensed teachers and then talk to them, I told them look… you are not recognized as professional teachers, you are like casual labourers… also, think of the funny names given to you such as 'voda faster', try to feel the pain you are getting because of these funny names, please try as much as you can before the expiry of your teaching license … please obtain admission to any residential diploma teacher training college and we will support you…. (District Education Officer II, phase 1 interview 10)

He suggested a residential diploma course would be an appropriate route to enhance the teachers' professional teaching skills because many of them were not recognized as professional teachers by the community and even the Government and they needed qualifications.

4.5 Summary of licensed science teachers' professional learning needs

The participants' views, documentary analysis and classroom observations showed that licensed science teachers have underdeveloped PCK, in aspects like subject content knowledge for teaching specific science subjects, (such as physics, chemistry, biology and mathematics), planning, understanding students' learning and how to assess science knowledge during and after instruction. Their schemes of work were often found partially or incorrectly filled in, and they were unable to state clearly the lesson objectives and lesson competencies. This study also indicated that licensed science teachers appear unable to construct higher-level cognitive questions for testing analysis, synthesis and evaluation levels according to Bloom's taxonomy of knowledge. Apart from their inability to construct higher-level cognitive questions, licensed science teachers were also found to have a problem constructing test items using accepted principles of test construction and they rarely used the table of specifications. In order to address their underdeveloped PCK, licensed science teachers suggested that they needed professional development and the content of any PDI should include preparation schemes of work and competency-based lesson plans, learner-centred assessment strategies, understanding learners with special learning needs and specific subject content knowledge.

4.6 Licensed science teachers' effectiveness in using learner-centred instruction

This section reports on the challenges that licensed science teachers perceive they face in teaching the learner-centred curriculum. It also reports on their effectiveness in providing learner-centred instruction, which is the recommended method for teaching lessons in the Tanzanian science curriculum. The major themes that emerged during the discourse and classroom observations were licensed science teachers' inadequate understanding of learner-centred teaching methods, and the perceived barriers to implementing learner-centred instruction in the Tanzanian classroom context.

4.6.1 Licensed science teachers' understanding of learner-centred teaching methods

The licensed science teachers were asked to describe learner-centred teaching strategies and what they know about learner-centred instruction. The findings from interviews indicated that licensed science teachers had only a partial understanding of the purposes of learner-centred teaching and assessment strategies and what they might involve. For example, when asked about learner-centred teaching methods they referred to 'participatory teaching methods' as methods that keep students busy during the lesson to allow them to conduct classroom discussions. Sungura thought that a learner-centred teaching method is involves students participating in group discussion but he was not able to define or give explicit examples of learner-centred teaching methods.

> Of course I don't remember the exact examples of learner-centred teaching strategies, but what I can say is that learner-centred teaching methods are those that use participatory approaches, such as students being allowed to conduct group discussion during the lesson in the classroom. (Sungura, phase 1 interview 5)

Three licensed science teachers, Safari, Manimo and Pombe, considered that learner-centered instruction was an opportunity for students to take responsibility for their own learning. They believed that students are knowledgeable, are sources of knowledge, and construct their own knowledge.

> I think that learner-centred teaching methods mean that the teacher is not the source of knowledge but simply guides students' learning. Students are the source of knowledge and can discuss each and every thing in the classroom and they can learn on their own … students come from different [geographical] areas and backgrounds and have had different experiences, and so as a teacher you have to share knowledge with them. This means that during the teaching process you just pose an idea concerning the subject matter and give student time to discuss it because they know something. (Manimo, phase 1 interview 4)

Pombe saw the teacher's role as supportive, providing information as needed

> During the participatory teaching method… students usually should have the opportunity to discuss the lesson on their own and as a teacher my role is to provide extra explanation about the lesson to the students. (Pombe, phase 1 interview 2)

Safari comments:

> I think learner-centred approaches refer to participatory teaching methods that we use to keep students busy in the classroom. I usually use group discussion by forming groups of four students, and leaving them to discuss the topic. This is the method called Jigsaw, whereby you develop home groups, then you develop expert groups and then you combine them and everyone goes back to the home group and each group leader will help to teach others and do the presentation. (Safari, phase 1 interviews 3)

Nonetheless, observation of Safari, Manimo and Pombe in the classroom indicated that their instructional practices contain far fewer elements of learner-centred instruction than their views expressed suggested. Their lessons were dominated by teacher-centred approaches. Observations revealed that most of the teachers were using the traditional ‘chalk-and-talk’ style of teaching with students silently copying what was written on the blackboard (Appendix 20 lessons narratives). For example, in one classroom observation, when Sungura was giving an 80-minute lesson about ‘elementary astronomy’ to Form 4 physics students, he did so without asking any questions or being asked questions by the students.

Only one teacher was able to identify some appropriate examples of learner-centred strategies. Tiita stated that: “learner-centred strategies are like demonstration, group discussion, experimentation, role play and simulation... I think these are some of the learner-centred teaching methods used in the classroom” (Tiita, phase 1 interview 6). While Tiita was able to mention some examples of learner-centred instruction, he also listed demonstration as one of the techniques of learner-centred instruction, which is generally considered a more transmissive teacher-centred technique. Tiita’s classroom observation revealed that he was not using learner-centred strategies despite his claim to use them.

Qwary explains how a learner-centred strategy should be carried out in the class, but how lack of equipment prevented this.

> Some of these strategies involving the learner-centred teaching of science subjects, particularly biology, for instance, when doing some experiments like doing a food test, the students themselves should do the activities or conduct the experiments, but due to the lack of science apparatus the teacher is sometimes forced just to do a demonstration for the class… (Qwary, phase 1 interview 1)

In summary, the findings indicated that licensed science teachers have a partial understanding of learner-centred instruction strategies.

4.6.2 Licensed science teachers' use of formative assessment techniques

This study was interested in finding out whether licensed science teachers' classroom practices are embedded with formative assessment methods as suggested in the Tanzania's science curriculum. When asked about their formative assessment practices the licensed science teachers responded by describing their use of assessment techniques such as quizzes, tests and oral questions and answers during classroom instruction. For example, Manimo made this comment "I ask my students oral questions during the teaching process to evaluate their understanding" (Tiita, phase 1 interview 6). Qwary also reported that:

> I usually use oral questions in the classroom to test my students' understanding during teaching, and for me this is an easy participatory assessment technique. Oral questions are easy to use because you can ask many students in the classroom. Sometimes I give my students quizzes or assignments. (Qwary, phase 1 interview 1)

Safari asserted that "in fact I usually use tests, quizzes, questions and answers … Therefore, after asking the questions I observe whether the students participate in answering them, and if they do then I know they have understood the lesson" (Safari, phase 1 interview 3). They also reported that they gave students exercises to evaluate their learning. Pombe explained:

> I usually give students exercises. Sometimes I use oral questions but I think exercises are better than oral question because you can check an individual student understanding when marking the assignment. Also, quizzes and tests can serve the same purpose… (Pombe, phase 1 interview 2)

However, despite the licensed science teachers' claims that they used oral questioning to evaluate students' understanding, classroom observations indicated that teachers rarely asked questions and in some lessons no questions were asked at all. Similarly students asked very few questions, and in some classes they did not ask their teachers any questions at all (see Table 4). In all the lessons observed the teachers did not appear to evaluate whether students had understood the lesson or not (Appendix 20 lesson narratives). These observations indicate that teachers' classroom practices are dominated by teacher-centred instruction with little use of formative assessment techniques to monitor student understanding of lessons.

Table 4: *Number of questions asked by teachers and students in each lesson observed*

	Teachers names and lessons observed												
	Manimo		Tiita		Sungura		Pombe		safari		Qwary		
Subjects observed	Mathematics	Physics	Physics	Chemistry	Physics	Biology	Biology	Biology	Chemistry	Biology	Physics	Biology	Chemistry
Questions asked by the teacher	2	4	6	2	0	3	4	0	4	1	1	0	3
Question asked by students	0	0	0	0	1	0	0	0	1	0	1	1	0

Source: Lesson observation notes

When asked how they evaluated students' learning some science teachers considered that the best approach for evaluating students' understanding of the lesson was through group work. Pombe's comments illustrate this view:

> You can assess students' understanding by looking at their participation during the lesson. For example, when they are discussing in groups you will see some students busy contributing, and then you will know who is participating and who is not. Then maybe those who are not participating have not understood the lesson; that is how I evaluate my lesson using participatory teaching methods. (Pombe, phase 1 interview 2)

Such comments support the finding that while licensed science teachers think they understand learner-centred assessment strategies they actually do not necessarily practise formative assessment in their teaching. In all the lessons observed the teachers did not appear to evaluate students' learning.

4.6.3 Licensed science teachers' views about students' participation in learner-centred teaching

In the study, licensed science teachers were asked to describe students' participation during learner-centred classroom instruction as the teachers' attitude to students' participation might help to reveal the reasons for their choice of certain learner-centred teaching methods to use in their classroom. Three licensed science teachers described how most students do not actually enjoy the use of learner-centred teaching methods. These sentiments are illustrated in the comments made by Manimo, Pombe and Qwary:

> Students' participation is very low when you use participatory teaching methods in the classroom, because I think of the difficulty of the language of instruction they encounter … in a class of 60 students you can have only two who raise their hands to answer the question. That is what I observed when teaching students using participatory teaching methods. (Manimo, phase 1 interview 4)

> Of course a few students like learner-centred teaching methods and these few are very happy when you do so, but many students do not participate, particularly those in Forms 1 and 2. I think if I opt to use learner-centred teaching methods some of the class will benefit and others will understand

> very little… many students enrolled in this school are academically weak, and some students can hardly read or write and so their participation is extremely poor. (Pombe, phase 1 interview 2)

> Of course in my school most of the students don't like this method because sometimes they think that the teacher is the one who knows each and every thing and is the one who is supposed to teach them. What the students need is just a teacher to explain each and every thing concerning the lesson and they will like your subject. (Qwary, phase 1 interview 1)

On the other hand two licensed science teachers argued that students learn more effectively when taught using learner-centred teaching methods. Tiita commented that "participatory teaching methods are good because at the end of the lesson or course the learners become competent and will acquire higher-order thinking skills and so students love participatory teaching methods" (Tiita, phase 1 interview 6). However, Safari cautioned that for learner-centred teaching methods to result in effective student learning they should be well planned. Safari reported that:

> Students are very happy to be taught using learner-centred teaching methods, but if you have not planned the group activities in advance the students will not understand the lesson… Forms 4 and 3 students usually contribute well to discussions. (Safari, phase 1 interview 3)

Despite the differences in teachers' opinions about learner-centred teaching methods, they all agreed that Forms 1 and 2 students do not like teachers using learner-centred teaching methods very much. The teachers' descriptions indicate students' participation is limited in classes taught using these methods and classroom observations confirmed this finding. During the classroom observations teachers were found rarely involving students and in the few times when teachers did encourage students to be involved by asking them questions some students kept quiet, did not contribute and exhibited shyness. Qwary felt that students' inadequate prior knowledge of the content of science subjects may be behind students' lack of engagement during learner-centred classroom discussions.

> Sometimes due to their lack of prior knowledge about my subject, the students do not contribute when I use learner-centred teaching methods like group discussions. I think students do not understand some of the content of the subject I teach, and so it is difficult for them to understand the lesson and then contribute. (Qwary, phase 1 interview 1)

Sungura felt his students were ill-prepared for learner-centred teaching.

> Actually students' participation is not good because few of students selected to study in this school have motivation to study in secondary schools…if the foundation of using participatory teaching methods was not built in primary schools, then it will be very difficult to apply learner-centred teaching methods in secondary schools… the roots of the problem stem from the fact that primary school students are not used to participatory teaching methods. (Sungura, phase 1 interview 5)

During the interview Pombe admitted that "I use learner-centred teaching methods very rarely in my teaching … I can't lie to you that I am using learner-centred teaching approaches when I am not" (Pombe, phase 1 interview 2). Two other licensed science teachers reported that they use learner-centred teaching methods occasionally in Forms 3 and 4 because these classes are less crowded and students can express themselves in English. Tiita said:

> I often use learner-centred teaching methods when teaching Form 3 students because there are few of them in the classroom. I use learner-centred strategies when the topic is difficult and if it involves manipulation, such as calculation and verification of principles or laws. (Tiita, phase 1 interview 6)

However, classroom observations during phase 1 of the study revealed that, even in Form 3 classes, licensed science teachers were not using learner-centred teaching methods. It was observed that teachers in higher forms tend to ask few questions while in lower forms they rarely ask questions. Also, observation of teachers in the classroom showed that they wait longer in higher forms for students to respond to the few questions they have asked than in lower forms.

4.6.4 Barriers affecting the use of learner-centred teaching methods

The licensed science teachers highlighted a number of factors they considered a barrier to the implementation of learner-centred teaching methods, including English as the medium of instruction, the lack of teaching and learning materials, textbooks, laboratory equipment and chemicals, and large classes. These barriers are reported in the next section.

4.6.4.1 English as the language of instruction

The licensed science teachers reported that using English as the medium of instruction was the main barrier in the implementation of learner-centred instruction. They stated that learner-centred teaching methods are difficult to implement, particularly for teaching lower grade students, such as Form 1 and 2 classes, because of the students' low level of proficiency in English, the medium of instruction. Safari comments:

> On a few occasion I use learner-centred teaching methods when teaching Forms 3 and 4, but in Forms 1 and 2 it is very difficult because they are not conversant with English ... If you divide Forms 1 and 2 students into groups they keep silent, and so as the teacher you will be going round the groups explaining each and every thing to them. (Safari, phase 1 interview, 3)

As English was not the medium of instruction in primary schools the teacher felt this lack of exposure to the language affected the students' ability to express their ideas in English.

> You know language is a problem … the language of instruction is affecting students, in particular students in the lower grades because they were not used to being taught in English in primary school … they are used to

> Kiswahili, which is the medium of instruction in primary schools in Tanzania. (Qwary, phase 1 interview 1)

> Another challenge in implementing learner-centred teaching methods is the English language, which is the medium of instruction. … the language of instruction is affecting students because English is new to them. I suggest that if we want to improve the ability of students to understand English they should start using it as the medium of instruction in primary schools. (Manimo, phase 1 interview 4)

> If a student in primary school can hardly read a passage in Kiswahili, I think he or [she] will not be able to study well in secondary school because English, which is the medium of instruction, is new to them. (Sungura, phase 1 interview 5)

The teachers' practices in the first phase of the study also corroborate their claims that students were unable to study efficiently through the use of English. During the lessons the mixing of English and Kiswahili by students and teachers was observed. When teachers entered the classroom they started talking using English but after about 10 minutes of teaching in English most changed the medium of instruction to Kiswahili and started elaborating lesson concepts in Kiswahili, then they went back and forth in English and Kiswahili. The observer also noted that the teachers had difficulties explaining lesson concepts in English.

4.6.4.2 Lack of teaching and learning materials

The licensed science teachers also reported the lack of teaching and learning materials as a challenge that prevented them from teaching students using learner-centred methods. They reported that many community secondary schools classrooms were impoverished since they lacked laboratory apparatus, laboratory chemicals, teachers and students' textbooks.

> There are many challenges in using learner-centred teaching methods, such as the lack of textbooks, teaching and learning materials and laboratory

> apparatus. Therefore, if you want to use a learner-centred teaching approach you have to find textbooks for each group of students… (Safari, phase 1 interview 3)

> Of course the main challenge in teaching science through participatory teaching methods is ... the lack of student textbooks, laboratory apparatus and chemicals. (Manimo, phase 1 interview 4)

> …involving students becomes very difficult because many of them do not have textbooks. If each student has his own textbook learner-centered teaching methods can be easily used because students will be able to read the topics on their own. (Sungura, phase 1 interview 5)

Clearly the inadequate supply of teaching and learning materials it seems discouraged teachers from implementing learner-centred pedagogy.

4.6.4.3 Heavy teaching loads

Along with a the lack of teaching and learning materials, one teacher reported that in her school, the teachers including herself were overloaded because they teach more than the recommended number of hours per week. Pombe commented that:

> This school has a shortage of teachers and the few that are available have a heavy weekly teaching load. For example, each week I teach 8 streams (A,B,C and D) in both Forms 1 and 2 … if you decide to use learner-centered teaching methods for all classes you will faint in the classroom, and you will not finish your syllabus by the end of the year. (Pombe, phase 1 interview 2)

Tiita similarly reported that "inadequate time because of many hours of teaching because of shortage of science teachers … for example, last year I was teaching physics for the all classes (Tiita, phase 1 interview 6).

This time pressure made learner-centred pedagogue unrealistic choice in their opinions because completion of the syllabus would be unachievable.

4.6.3.4 Large class sizes

The case study schools were found to have insufficient classrooms to accommodate students according to the required teacher-student ratio of 40 students per room. This shortage of rooms meant teachers were forced to combine two classes into a single class. They reported that the small number of classrooms in relative to the number of students was another barrier affecting the implementation of learner-centred teaching methods. This is illustrated in the comments made by Sungura, Manimo and Qwary:

> The first challenge is the overcrowded classes, because there are many more students in the classroom than the recommended teacher-student ratio of 40 students per class … for example, some classes have 80 students … and there is only one textbook, therefore as the teacher you will be teaching while at the same time writing notes for students on the blackboard. (Sungura, phase 1 interview 5)

> I don’t use learner-centred teaching methods frequently because the learning environment does not encourage the use of the learner-centred teaching methods…also classes are overcrowded. I mostly use questions and answers when teaching the class, which is a two-way discussion. (Manimo, phase 1 interview 4)

> I have being using participatory teaching methods in my classes but not often because of the lack of learning materials, overcrowded classrooms and the shortage of teachers. Here you may find a single classroom having more than 50-65 students instead of 30-35 students. Therefore, the strategies I usually use are teacher-centred teaching methods, particularly the lecture method. (Qwary, phase 1 interview 1)

The teachers appeared unable or unwilling to employ learner-centred teaching methods in these overcrowded classrooms. During classroom observations, particularly chemistry and biology lessons, the classes were obviously congested and in some lessons more than 70 students were observed in one classroom. Forms 1, 2 and 3 classes were noisy and teachers struggled to manage the classes while teaching.

In conclusion, licensed science teachers had a partial understanding of how to teach students using learner-centred teaching methods, tending to conceive them as students just participation in group discussion during the lesson. The study also revealed that these teachers believed that oral questions, tests and quizzes were the best learner-centred assessment strategies. They had the perception that students in Forms 1 and 2 do not like being taught through learner-centred teaching methods, although their classroom practices in Form 3 and 4 were no different as they claimed. The licensed science teachers believed that English as the medium of instruction, the lack of laboratory apparatus, teaching and learning materials and the high student-teacher ratio hindered the implementation of learner-centred teaching methods in Tanzanian community secondary schools.

4.7 Existing professional development programmes for supporting licensed science teachers

This section reports on the accessibility and quality of teachers' professional development programmes in place for supporting licensed science teachers. When asked about the existing professional development programmes for licensed science teachers, two themes emerged from the data: the lack of school-based professional support for licensed science teachers and the perceived barriers to upgrading opportunities for licensed science teachers via the available distance learning mode.

4.7.1 Lack of school-based professional support for licensed science teachers

The interviews with headmasters, licensed science teachers and the regional school inspector indicated that community secondary schools do not have any internal professional development programmes for supporting licensed science teachers. The licensed science teachers reported that they were initially supplied with teaching artefacts such as schemes of work, syllabuses and textbooks, but without any mentoring or professional development support. When teachers were asked about school-based professional development support opportunities they commented:

> What can I say but no, because since I was employed here in 2006 up to this moment there has been no training or even a workshop especially for licensed science teachers to develop their profession. (Qwary, phase 1 interview 1)

> I never received any profession development training as it has never happened at this school. I have been teaching in this school for almost a year now, and have seen none of my friends attending any seminar. (Safari, phase one interview 3)

> This is [a] dream, as no professional development training is available for licensed science teachers. Absolutely no[ne]… I never attended any in-service training courses or seminars. (Sungura, phase 1 interview 5)

> When I reported to this school I immediately enrolled in the Open University of Tanzania, but I have never received any professional development training since I came here, and there is no special training package for licensed science teachers or even for licensed arts teachers. (Manimo, phase 1 interview 4)

They also commented that it was the qualified teachers who receive the few professional development opportunities. Pombe described how: “I have never attended any in-service training programme; usually qualified teachers are the ones who go to the in-service workshops here at school" (Pombe, phase 1 interview 2). Pombe's comments were echoed by the Tlawi secondary school headmaster. He said:

> The problem is that the available in-service training opportunities are not meant for licensed teachers ... but for qualified teachers. These seminars are organized by the district, which requested us to send only qualified teachers because licensed teachers or Form 6 leavers are unreliable as they might renounce teaching at any time. The attrition rate of licensed teachers is high and so no-one appoints them to attend professional development seminars. The strange thing about these seminars is that instead of helping teachers with a poor pedagogical background, such as licensed science teachers, their focus is on supporting the qualified teachers. (Headmaster, Tlawi secondary schools phase 1 interview 8)

The perceived high attrition rate of licensed teachers appeared to prevent them from benefiting from the few professional development opportunities. Mentoring and peer-coaching also appeared to be unavailable in some schools.

> No. There is no peer coaching support here in my school. When I reported for the first time to my workstation I was just given the textbooks and the syllabus. I was allocated the classes to teach and that is all, and then I started teaching. I just used my induction course knowledge. (Tiita, phase 1 interview 6)

> In Government secondary schools peer-coaching is a very rare activity, but it is done in private schools. I didn't get any peer-coaching or mentoring when I started teaching … I got advice from the zonal school inspector last year when he inspected the school on how to teach in the classroom. (Sungura, phase 1 interview 5)

Another licensed science teacher saw peer-coaching as simply providing the novice teacher with teaching and learning materials and introducing him/her to the classroom.

> I received peer-coaching from one of the experienced teachers who was teaching here at the time I reported, but he was appointed to be a headmaster and was transferred to another school two years ago. This teacher escorted me to the classroom and introduced me to the students and then he left me with them so I could proceed with teaching them … but he never checked my teaching in the classroom to see how I am teaching my students. (Manimo, phase 1 interview 4)

By and large, formal professional learning opportunities for supporting licensed science teachers did not exist in the case study schools. Schools-based professional learning activities such as peer-coaching or mentoring were not part of the culture of the schools.

4.7.2 Upgrading qualifications via distance learning mode

This section reports on the perceived limitations facing licensed science teachers in upgrading from a high school qualification to a Bachelor degree in teacher education via the Open University of Tanzania (OUT) distance learning mode as recommended by the Tanzanian MoEVT. Only three out of six teachers who participated in this study took up this opportunity of upgrading their qualification via OUT. When the teacher talked about the obstacles to studying via the distance learning mode, three themes emerged from the data: the rural-urban divide, the lack of financial support and the teaching workload caused by the shortage of science teachers.

4.7.2.1 Rural-urban divide

The licensed science teachers reported that the proposed OUT distance learning approach works well for teachers employed in urban and city centres secondary schools. However, it was evident from their responses that teachers employed in rural secondary schools came up against many obstacles. Qwary's comments exemplify some of these problems:

> One of the barriers is the location of the school where each of us was posted. Licensed teachers who are enrolled and currently studying at the OUT are those deployed in urban centres, but for us who are working in rural areas it is very difficult to study through the OUT approach. Even if you are enrolled you will find it very difficult to study, because you will fail to obtain learning materials and you will need a computer and internet access, which are not available in rural areas. (Qwary, phase 1 interview 1)

The isolation of their rural schools often meant there was a lack of electricity, computer, internet access, libraries, and books to support them in their studies.

> …another challenge of studying through the distance learning approach is that our school is far away from the OUT regional headquarters. The OUT simply provides the student with the course outline. Therefore, there are no learning materials or learning facilities, such a computer, internet access and textbooks. Also in our environment there is no library in which to find the books we need. (Pombe, phase 1 focus group discussion)

> The OUT does not have enough learning materials, particularly books, and cannot provide internet access, which is central for studying because of the lack of books. Apart from that in our houses there is no electricity, which is a big barrier for me because I spend the day teaching, and a good time for doing assignments is at night, but due to the lack of power I failed to continue with my studies at the OUT. (Manimo, phase 1 interview 3)

The licensed science teachers also reported that studying science subjects at the OUT is more of a problem for them because science subjects involve practicals and these practicals were not offered at OUT regional centres.

> It is difficult for licensed science teachers to study through the OUT approach, because you have to travel a long distance to attend the practical

> sessions which are conducted at designated centres, such as the University of Dar es Salaam and Sokoine University of Agriculture, which are very far away from our schools. Also you have to incur the cost of travelling and living expenses during the practical sessions. (Sungura, phase 1 interview 5)

The licensed science teachers also blamed the Tanzania Government and the OUT because the open distance learning programme failed to meet their needs. The programme was introduced as an alternative approach for upgrading licensed science teachers without any thorough research. These views are illustrated in comments made by Tiita:

> The Ministry of Education and the OUT did not do enough research into licensed teachers’ working environment because we licensed science teachers are working in an unsympathetic environment, I mean in remote areas where there is no power, internet connection or phone lines and the roads are poor, and so it is very difficult for most of us to continue studying at the OUT. (Tiita, phase 1 interview 3)

One teacher also claimed that if the situation remains the same, she is not going to advise anyone to study via the OUT. Pombe had this to say:

> Personally I would not advise anyone to register at the OUT unless they have improved the situation or you are in the city centre, but if you are in rural area like this it is very difficult for a teacher to study and succeed. (Pombe, phase 1 interview 2)

These licensed science teachers’ views reveal that teachers deployed in rural areas are disadvantaged when studying via the open distance learning approach, they struggle with the availability of learning materials, access to the internet and library services and having electricity, which are essentials for the successful use of the distance learning approach.

4.7.2.2 Inadequate study time due to heavy teaching load

The licensed science teachers also reported that they had no time to study using the distance learning approach because they teach so many hours per week and the school management requires them to focus on their teaching duties in preference to studies. Such feelings are illustrated in comments made by Manimo, Safari and Pombe:

> One of the challenges of studying via the OUT is the lack of time to study because I am working as a full-time teacher, and the school management doesn't consider me a student. I am doing all the activities that are supposed to be done in school, but it is very difficult for a licensed teacher to prepare himself [herself] for his university papers. This is one reason why we usually take a long time to finish our studies at the OUT. Sometimes when you ask for permission from the headmaster to attend face-to-face lecture sessions, the headmaster will ask you to finish all your weekly activities first before you can travel for tests and face-to-face lecture sessions. (Manimo, phase 1 interview 4)

> You know that most community secondary schools have an acute shortage of teachers and sometimes there is only one teacher teaching biology for the whole school and so this keeps you busy teaching all day instead of doing your university assignments and papers. (Tiita, phase 1 interview 3)

> I get a lot of problems studying my course at the OUT, because I work as a full-time teacher while studying at the same time. There is no free time to read and permission is usually only granted when you are going for an examination. I think my performance will also be affected because I don't have enough time to prepare for tests and examinations. (Pombe, phase 1 interview 2)

These licensed science teachers' experiences reveal that the heavy teaching workload does not allow them reasonable time to study for their OUT course. They feel unable to prepare themselves sufficiently for tests and examinations and school and school management does not provide them with support to carry out this study.

4.7.2.3 Lack of financial support for the distance learning programme

The participants also blamed the Tanzanian Government for failing to fulfil its promise of financial support for those licensed teachers who have registered and are studying via the OUT distance learning approach. Manimo said

> I blame the Tanzanian Government because during the induction course they promised that they would pay tuition fees and provide a book and accommodation and living allowance, but they paid only the tuition fees. (Manimo, phase 1 Focus group discussion)

Another licensed science teacher reported that the government had overlooked the financial burden facing them when participating in the distance learning programme, such as paying for food and accommodation and transport during tests, examinations and face-to-face lecture sessions. Pombe explained:

> …another challenge is the costs we usually incur during the face-to-face sessions such as paying for food, accommodation and transport during tests and examinations. Therefore, it is very hard for licensed science teachers to manage all these costs because we are only paid 80% of the diploma teacher's salary before tax is deducted. Although the tuition fees are paid by the Tanzanian government, the cost of living is too high for licensed teachers to manage. (Pombe, phase 1 interview 2)

> …other barriers are personal ones for example, family dependence and the meager salary, which is not enough to provide for your personal needs and for you to study. (Sungura, phase 1 interview 5)

It is evident from the licensed teachers' responses that they felt there were many barriers to studying via the OUT distance learning mode.

4.8 Licensed science teachers' suggestions of factors facilitating establishment of teachers professional learning communities

The licensed science teachers, education officials and headmasters were asked to identify the factors they thought would be useful to consider when developing school-based PLCs of teachers in the context of Tanzanian secondary schools. They identified three major features that might lead to the establishment of PLCs of teachers: the establishment of ward teacher resource centres; the provision of financial support; and good school leadership.

4.8.1 Establishment of teachers' resource centres

The licensed science teachers suggested that to establish teachers' PLCs a fully equipped teacher resource centre would be required that could be used by teachers as a meeting place where they could share their experience of teaching. Not only should the resource centre be well equipped with teaching and learning materials, there should also be facilitators available to support the community of teachers. In addition government should provide the necessary financial support to set up these centres.

> I think in order for PLCs to be successful there should be a centre where the teachers from different schools could meet. Also, the provision of learning materials and a facilitator of the training should be part of the plan. If possible it would be a good idea if the government established resource centres for secondary school teachers in each ward. (Manimo, phase 1 interview 4)

> I think if we could have a small library at the school with important learning materials it would help licensed teachers and other teachers as well, or the ward council could construct a small teachers' resource centre where all teachers could go to study on their own and sometimes meet as a group and learn something, assisted by an expert. Also short courses could be conducted at this centre to help licensed teachers currently studying at the OUT. (Pombe, phase 1 interview 2)

The idea of establishing a teachers' resource centre was also supported by the regional school inspector and district education officer. The regional inspector commented that:

> You know our role as school inspectors is to advise the employer…. the immediate approach we have suggested to the employer is to make use of teachers' resource centres. You invite teachers from different schools to the selected resource centre, as well as experts in teaching methodology to teach teachers about new teaching methods. (Regional school inspector, phase 1 interview 11)

Currently, in Tanzania some district headquarters have primary school teacher resource centres constructed either by the government or with donor support and these are used by primary school teachers as meeting centres during the professional development workshops. One District Education Officer thought these primary school teachers' resource centres might be useful for secondary schools while they are doing plans to establish resources centres for secondary school teachers.

> … At this moment we don't have PLCs of teachers here in the district. But we have begun a discussion here at district level about establishing PLCs in schools… we are going to ask the heads of schools to plan and establish PLCs in their schools using the few available resources in primary school teachers' resource centres. Although these resource centres were purposively built for primary school teachers, we can use them for secondary school teachers. (District Education Officer II, phase 1 interview 10)

These participants' views evidently see teachers' resource centres as key to the successful establishment of PLCs of teachers in the context of Tanzanian community secondary schools.

4.8.2 Adequate financial support and good school leadership

As alluded to earlier, the study participants also reported that a shortage of funds is another barrier to the establishment of PLCs of teachers in the district and schools. They are pessimistic about successfully establishing a community of teachers in ward secondary schools because of inadequate funding from the Government, as illustrated by the following comments made during the interviews:

> The major challenge concerning the establishment of PLCs in ward secondary schools is the insufficient funds we receive from the Government… in order to provide good in-service training you need to invite experts from the Ministry of Education or the zone, who will need to be paid an allowance for living expenses, known as a per diem. (District Education Officer II, phase 1 interview 10)

> Professional learning communities require resources such as learning materials, a facilitator and funds to cover the cost of transport to the teachers' resource centres. I think all these need the support of the school management and district education office because it will involve money. (Manimo, phase 1 interview 4)

> The Ward Education Officer and headmasters must show leadership in facilitating teachers' PLCs. The Ward Education Officer should get the support of head of schools, who should support the facilitators and teachers by providing them with the return bus fare to attend in-service training seminars. (District Education Officer I, phase 1 interview 9)

The Ward Education Officer also reported that teachers might not be interested in attending professional development training seminars if no allowance is provided for attending them, because they have been used to getting these allowances:

> …the challenge will be whether the teachers themselves will respond positively because we don't provide an allowance for them to attend

> seminars, nowadays. When we invited teachers to a training event in the past they knew they would get something and so they are used to this. (Ward Education Officer, phase 1 interview 12).

Sungura was optimistic that if professional development is conducted at ward level there would be no need to pay the teachers for attending because they would be enhancing their professional knowledge. Sungura commented that:

> It is very important that, if in-service training is conducted at ward level, it should be compulsory for all teachers, because in the ward you would not need funds for supporting the programme as it will be very close to our work station. Also, the knowledge you would get in this training would be used for the purpose of improving your job performance. I think there would be no need to give a cash incentive to the trainee. (Sungura, phase 1 interview 5)

The participants clearly saw a need for teachers' resources centres to be financially supported if PLCs are to be successfully established.

4.9 Summary of the chapter

The professional learning needs of licensed science teachers were identified through observing individual teachers in the classroom, one-to-one interviews, documentary analysis and focus group discussion. The cross-case analysis of the four cases resulted in the following key findings:

- Licensed science teachers believe that effective science teaching and their classroom teaching practices are negatively influenced by the lack of teaching and learning resources;
- Licensed science teachers had limited subject content knowledge;
- Licensed science teachers were found to have underdeveloped components of PCK, in particular knowledge of instructional strategies, knowledge of student, knowledge of student and assessment;
- Licensed science teachers had a limited understanding of learner-centred teaching methods and rarely used them in their classroom;

- School-based professional development programmes to support licensed science teachers working in community secondary schools do not exist; and the upgrading of licensed science teachers via the distance learning approach was ineffective for teachers working in rural schools; and
- The establishment of PLCs of teachers depends on the availability of well-equipped teachers' resource centres at ward level that are financially supported.

On basis of these findings the researcher decided to design and implement a PDI for one month to address the licensed science teachers' limited PCK in order to broaden their instructional practices and meet their PCK needs. The PDI adopted the tenets of PLCs of teachers, teacher network model and individually guided professional development model to enhance licensed science teachers PCK. The impact of the PDI on teachers' PCK is reported in Chapter 5.

CHAPTER 5: PHASE TWO-FINDINGS
THE IMPACT OF PROFESSIONAL DEVELOPMENT ON LICENSED SCIENCE TEACHERS' PCK

5.1 Introduction

This chapter presents the professional development intervention (PDI) that was designed and implemented to address the identified professional learning needs of licensed science teachers. The data were generated using the researcher's planning documents and reflection notes, teachers' self-evaluation reflection notes, post-focus group discussion, professional development workshops reflection notes and observation of teachers' classroom practices. The impact of the PDI on teachers' classroom practices is also reported in this chapter, in particular, the perceptions of licensed teachers of the effectiveness of PDI and the evidence of PDI in meeting teachers' professional learning needs, and the impact of the PDI on student learning.

5.2 Professional development intervention (PDI)

This study investigated licensed teachers' professional learning needs, in particular PCK and their ability to use learner-centred teaching methods. The findings from the first phase (Chapter 4) indicated that the licensed science teachers have inadequate PCK and they need support to strengthen their PCK. In order to meet the licensed science teachers' PCK development needs, a PDI programme was designed and implemented by the researcher. The licensed science teachers engaged in the professional development workshops that were broadly aimed at improving their PCK. They were given both academic journal papers and professional teacher education articles to read individually and prepare short summaries to present at follow-up workshops. During the workshops the teachers were involved in group discussion on new concepts arising from the papers, individual studies, group work studies and from the researcher, particularly strategies for improving their PCK. The professional development design allowed teachers time for individual reflection, collaborative reflection and to practise the new skills that had learnt in their schools. The workshop sessions were organized to allow the licensed science teachers to implement and practise the new skills in the classroom before the next workshop. They were then given the opportunity to reflect on their classroom experience of these practices in the subsequent workshop(s) and as members of teachers PLCs in their respective schools. The licensed science teachers' classroom practices were evaluated eight months after the PDI. The licensed science teachers' classroom practices were observed to examine whether or not the professional development had had an impact on their classroom practices. To indicate how each licensed science teacher had benefited from the PDI they were given reflective self-evaluation questions to answer individually. Also, students' focus group discussions were conducted to obtain their views on whether or not their teachers had been using learner-centred teaching methods on a daily basis. Organisation of the professional development workshop is reported in the next section.

5.2.1 Professional development workshop organisation and implementation

The professional development workshops were conducted at the Babati District Primary School Teachers' Resource Centre. This location was proposed by the participants as a convenient place as it was easily accessible by local bus. Permission to attend the workshops was granted by headmasters on the condition that the licensed science teachers taught their morning classes from 8.00-9.00 am on Thursdays and Fridays. The licensed science teachers reported to the workshop centre around 10.00 am and sessions commenced around 11.00 am and finished at 4.00 pm. The PDI was organised into eight workshop sessions spread over four weeks with two days' attendance per week (Thursday and Friday). The choice to implement the skills gained from the workshops was at their personal discretion. The licensed science teachers were not forced to practise the ideas gained from the PDI workshops, although they were encouraged to use these skills in their classroom. Therefore, implementing the learnt skills would depend on a teacher's personal understanding and availability of support structures in the school environment. The professional development learning material was organized into eight modules (see Table 5), covering a wide range of the identified professional learning needs of the licensed science teachers. The methods used during the implementation workshops include participants' panel discussions, individual licensed science teacher's presentations, group discussions, and the researcher's Power Point presentations. The content of the workshop sessions is discussed in brief in the next sub-sections.

Workshop one. Two modules were studied during the first workshop session. The first module was about potential PLCs of teachers and how these communities would improve teachers' classroom practices and students' learning outcomes, while the second module was about lesson planning. The first module was intended to help licensed science teachers gain an understanding of working together as learning communities of teachers. The researcher believed that their understanding of the characteristics of PLCs was likely to help them in developing a culture of working as a community of professional teachers, sharing the skills gained and supporting each other in teaching challenging science content. The second module was on lesson planning, which was considered to be the heart of teaching and learning in the teaching profession. This module introduced licensed science teachers to the basics of lesson preparation, such as writing a statement of objectives, the use of action verbs in lesson planning, the selection of teaching and student learning materials, evaluating the lesson, assessment strategies and writing classroom level lesson 'competencies'. Lesson competency/competencies is a recently introduced concept in Tanzanian science education curriculum, and is defined as "a general statement detailing the desired knowledge, [behaviour] and skills of student" (Hartel & Foegeding, 2004, p. 69) that are intended to be achieved by the end of the instruction session or course programme. Also, different lesson plan templates from their schools were evaluated. The licensed teachers were given the opportunity to evaluate their old lesson plans in terms of the key features of well stated lesson objectives and students' lesson competencies.

Table 5: *Content of the professional development workshops*

	Module	Content covered	Teaching and learning strategies used to teach the module contents
Workshop 1	Module 1: understanding Professional learning community (PLC)	• Concept of PLC • Characteristics of PLC of teachers • Role of PLC in addressing teachers' PCK and students' learning outcomes	• Group work presentation (after reading PLCs articles) • Critically examining two lessons as a PLC of science teachers and then members identified some possible students' naïve ideas • Power point presentation (researcher)
	Module 2: Lesson planning	• Preparation of specific learning objectives and lesson competencies • Selecting correct action verbs (Blooms Taxonomy) • Preparation of lesson plan • Selecting teaching approach according to class size, age and interest • Presentation skills-loudness of voice, positioning, mannerisms, questioning strategy including use of waiting time and reinforcement.	• Evaluating sample of old lesson plans and schemes of work • Teaching of sample lesson to the group • Panel discussion on the ways of improving the presented lesson • Writing a reflection on the presented lesson • Power point presentation (researcher)
Workshop 2	Module 3: Characteristics of learner-centred teaching	• Differences between learner-centred and teacher-centred approaches to teaching • Characteristics of learner-centred teaching • Strategies of teaching science using learner-centred approach • Assessment of learner–centred teaching approach	• Group work presentation and discussion • Micro-teaching of learner-centred science lesson • Writing reflection on each lesson

	Model 4: The conceptions of teaching and learning science	• Examining the concept of teaching and learning (i.e. is it to Promote: transmission, interaction, or transformation, an art or a science?) • Describing and demonstrating interactive and transformative approaches (group tasks, plenary discussions, panel discussions, role playing, dramatization, case studies, etc.) of teaching	• Group work presenting summary of the articles. • Demonstration teaching conception by micro-teaching of selected topics in science subjects • Power point presentation (researcher)
Workshop 3	Module 5: Reflective practice in teaching science	• Exploring meaning of reflective journal • Learning to reflect on practice • How to use "EXPLORE' as reflective technique. EXPLORE is an acronym standing for "Examine," "Pair," "Listen," "Organize," "Research," and "Evaluate."	• Reading journal articles about reflective journals • Participants to develop reflective journals for teaching their subjects • Power point presentation (researcher)
	Module 6: Categories of knowledge base of teaching science	• Explore different knowledge base categories for teaching science • Examining the major sources of knowledge base of teaching • The use pedagogical reasoning in teaching science topics	• Workshop participants' presentations of a summary of the articles for workshop discussion • Power point presentation (researcher)
Workshop 4	Module 7: Formative and Summative assessment	• Discuss and practice formative evaluation through oral and written questioning and observation • Examine summative as opposed to formative evaluation • Setting and management of individual and group homework tasks and quizzes/tests	• Group work presentation and discussion • Teaching a lesson in classroom and demonstrating formative assessment while teaching • Reading formative and summative assessment articles • Workshop presentation
	Module 8: Portfolio as an assessment tool for science teacher	• Explaining meaning of the teaching portfolio • Content of science teaching portfolio • Purpose and uses of teaching science portfolio • Strategies for organizing science teaching portfolio	• Licensed teachers' group work presentation (workshop approach) • Developing a summary from journal articles about teaching portfolio • Power point presentation (researcher)

Workshop two. The second workshop covered modules three and four. Module three introduced the licensed science teachers to the broader concept of learner-centred education. The use of learner-centred teaching methods was discussed since it was considered relevant to licenced science teachers because the Tanzanian science education curriculum requires the teacher to use learner-centred instruction strategies in their classroom teaching. Module four focused on gaining an understanding of different conceptions of teaching science as it was thought licensed science teachers' understanding of these conceptions would help them make informed decisions when choosing relevant teaching method(s) for a particular science topic. The licensed science teachers were also introduced and encouraged to critically examine various concepts of teaching such as teaching as transmission, interaction, transformation, imparting of knowledge, facilitating of knowledge and conceptual /intellectual change.

Workshop three. Workshop three covered modules five and six. Module five introduced the licensed science teachers to the importance of reflecting on their teaching practices. The workshop covered the reasons for reflecting and developing reflective journals for evaluating their classroom teaching practices. Reflecting was considered crucial for the licensed science teachers, because this would help them to interpret their teaching experiences and develop a new understanding of classroom teaching. Also the teachers provided lesson plan templates containing a section requiring teachers to write a reflection on their lesson after teaching. It is believed that reflection helps teachers to re-evaluate their classroom teaching practices for the purpose of improving their next lesson so that students' learning can also be improved. Module six exposed the licensed science teachers to the ideas of Shulman (1986, 1987) concerning the knowledge base of teachers and the categories of knowledge that comprise this base. This module explored major sources of knowledge for teaching and how to use pedagogical reasoning and action to teach science. Teachers' understanding of the different categories of teaching knowledge was considered important because it helps to broaden their understanding of the teaching profession.

Workshop four. This workshop covered modules seven and eight. Module seven exposed the licensed science teachers to the use of formative and summative assessment in learner-centred education and they explored the different leaner-centred strategies for assessing students' learning during teaching. The emphasis was on how to use formative assessment strategies as part of their learner-centred teaching methods. Module eight exposed the licensed science teachers to the concept of the portfolio as an assessment tool for science teachers. Licensed teachers explored different types of teaching portfolios and how to use them as assessment tools. They also discussed the strategy of organizing the science portfolio and the nature of the content in the teaching portfolio.

In each workshop licensed science teachers were asked to provide feedback on the previous workshop by filling in an evaluation form. This forms contained reflection questions for each session and once completed the teachers submitted this reflective feedback at the next workshop session. These reflective notes were used to inform future sessions in the workshops and together with reflective discussions they were used to evaluate the effectiveness and impact of PDI by the researcher. The post-intervention focus group discussion and classroom observations were used to examine licensed teachers' perception of the effectiveness of PDI in addressing their PCK. These perceptions and licensed teachers' classroom teaching practices are reported in the next section.

5.3 Effectiveness of PDI in enhancing licensed teachers' PCK

The licensed science teachers' perceptions of the effectiveness of PDI in enhancing their PCK were evaluated using their reflection notes written during the workshops, transcripts of a post-intervention focus group discussion conducted after eight months and teachers' reflection notes written eight months after the PDI. Overall, the licensed science teachers felt that their participation in the professional development workshops had improved their PCK. These views are exemplified in comments made by Pombe and Safari:

> This training has helped me a lot. Because of this training I feel that I am a better teacher. This training has changed my practice because now I understand modern [learner-centred] teaching methods. I learned new teaching strategies that are useful for helping or guiding my students to understand my lesson. For example, before the professional development training I did not know the difference between student assessment and student evaluation and what to write in the assessment and evaluation section of the lesson plan. (Safari, phase 2 focus group discussion)

> This training was awesome because I learned new systems [methods] of teaching and especially it has improved my pedagogical content knowledge on how to teach students using learner-centred teaching methods rather than using teacher-centred methods. Though there are some challenges in practising the learner-centred teaching methods, the skills I gained is helping me a lot. (Pombe, phase 2 focus group discussion)

Sungura felt that as result of the PDI he was able to distinguish between the qualities of a professionally trained teacher and an untrained teacher. He commented:

> You know before these workshops what I knew is that anyone teaching in the classroom is a teacher but now I know that there is a difference between the untrained teacher and the professionally trained teacher. Yes, I have learnt that to teach effectively in the classroom you need to have pedagogical content knowledge. I know that understanding the content of the subject was not enough knowledge for teaching science. (Sungura, phase 2 focus group discussion)

Manimo also felt that the training had improved his understanding of teaching methods and the link between teaching and learning skills for conducting formative assessment during classroom instruction. Here he articulates an appreciation of PCK.

> I learnt some skills, in particular teaching methods. For example, I learnt how to teach my lesson using leaner-centred teaching [methods] strategies, and how to conduct formative assessment. These workshops helped me to understand that teaching is more than just presenting content to the learners but how to teach the subject content so that it is understood by the learners [students], that is what makes teaching a profession. (Manimo, phase 2 focus group discussion)

Tiita reported that the intervention was very useful and had improved his teaching style. He felt that he was now a professional teacher.

> This programme [professional development intervention] was helpful in the sense it changed my old teaching style which was mostly teacher-centred rather than learner-centred. It helped me to have high expectations of my job and I am now professionally transformed. (Tiita, phase 2 workshop reflection notes)

Manimo also reported that licensed teachers are now working as a PLC of teachers in his schools and this collaboration has helped to improve his teaching. He confirmed that "… due to interactions with other teachers in my school my weaknesses in developing students teaching and learning activities have been minimized" (Manimo, phase 2 workshop reflection notes).

On asking what specific skills they had acquired from the PDI, the licensed science teachers reported that they now know how to prepare lesson plans and schemes of work, and they are able to use learner-centred teaching methods. These teachers' feelings are exemplified in the following statements:

> I learnt many things but most important is how to teach using learner-centred teaching methods in the classroom, how to prepare a good lesson, how to teach students effectively and how to involve students during the lesson. I came to understand that when a lesson is well planned the teacher's confidence also increases during the teaching. (Safari, phase 2 focus group discussion)

> The lesson plan module was very helpful because before I didn't know the importance of preparing and using a lesson plan while teaching. For example, preparing lesson objectives in advance before going into the classroom has helped my lesson to flow well. Writing lesson objectives in advance has guided my teaching and my lessons have become more focused on students' needs. Now I can organise my lesson from simple concepts to more complex ones. I know in advance students' possible misconceptions before entering the classroom and I can address them. (Pombe, phase 2 focus group discussion)

Many teachers reported feeling more capable about teaching and learning by the improvement in their abilities.

> The professional development intervention helped me in many ways, for example, how to construct a lesson plan, how to write competency-based lesson objectives, how to write a lesson reflection, how to extract a scheme of work from the syllabus and how to develop measurable lesson objectives using action verbs. (Sungura, phase 2 focus group discussion)

> I learnt how to use action verbs (like define, list, describe, and differentiate, etc.) in writing a statement of lesson objectives. Now I can construct statements of lesson objectives which are measurable rather than using general words such as students to understand, students to know, students to learn and appreciate. (Manimo, phase 2 workshop reflection notes)

Manimo also felt that PDI had changed his understanding of teaching, in particular how to use teaching portfolios and reflective journals as a means of improving students' learning.

> I am using a teaching portfolio and reflective journal. I use students' reflective journals to get feedback on my teaching. I think the idea of introducing student reflective journals in teaching is a valuable innovation of professional

> development that I will remember forever. (Manimo, phase 2 post-intervention reflection notes)

In a similar vein, Pombe commented that "I am now familiar with how to use the portfolio to reflect on my teaching" (Pombe, phase 2 post-intervention reflective notes). In summary, the licensed science teachers' comments suggest that the PDI had a positive impact on meeting their PCK needs. In particular, they felt that through the PDI their classroom teaching had improved and they now knew how to construct lessons plans and teach a lesson that is understandable to students.

5.4 Impact of PDI on students' learning

The licensed science teachers also reported that their students had benefited from their participation in professional development workshops. They commented that students' motivation had increased in their classrooms and there was less absenteeism by students since they started using the skills gained from the PDI. Tiita claimed that:

> Teaching through participatory [learner-centred] teaching method[s] has raised students' interest so that they love my subject and absenteeism has also decreased. The use of participatory teaching methods encouraged creativity and collaboration among learners [students], which closed achievement gaps between learners [students] from different backgrounds. (Tiita, phase 2 post-intervention reflective notes)

> The students understood more easily when my teaching is learner-centred than before when I was using the lecture method … learner-centred teaching makes students more friendly and close to you, which makes it easier to deal with the problem of each student in the classroom. (Qwary, phase 2 post-intervention reflective notes)

The teachers also reported that the use of students' reflective journals motivated the sharing of knowledge among students in the classroom.

> Students were very interested in commenting on their classroom reflective journals. Students formed a collaborative network of sharing knowledge during and after the lesson for doing homework. My students become very quick to ask questions and sometimes other students responded to their fellow students' questions. (Safari, phase 2 post-intervention reflective notes)

> Through their reflective journals students know that their views are going to be used to improve the next lesson and they started commenting on their classroom journals. Students gained self-confidence since they are allowed to express themselves through group discussion. (Manimo, phase 2 post-intervention reflective notes)

Another teacher also reported that since she began using learner-centred teaching methods in her classes, students were working more collaboratively and their understanding of the lesson had improved. Pombe claimed that "students are now interested when I apply participatory [learner-centred] teaching methods in my class, there has been some improvement of their understanding of my subject, and they are participating fully in discussion and class work (Pombe, phase 2 post-intervention reflective notes)

Other licensed science teachers also felt that their understanding and subsequent use of learner-centred teaching methods had an impact on students' creativity. Pombe commented that:

> Leaner-centred teaching methods opened the window for students to show their creativity. My role was that of facilitating the learning. What I usually do now is to clarify the concepts that students have raised, and since I started using learning centred strategies students seem to be motivated to learn my subject. (Pombe, phase 2 focus group discussion)

The licensed science teachers' comments suggest that students have indirectly and directly benefited from teachers' improved PCK.

5.5 Students' views of licensed science teachers' use of learner-centred instruction

The researcher asked the students to comment on whether their licensed science teachers were using participatory teaching methods (learner-centred teaching methods) that involve them during teaching. Learner-centred teaching methods in Tanzania are usually known as 'participatory teaching methods' and students think that when teachers asked students to solve a question on the blackboard they are teaching using participatory teaching methods. Students' views were collected using students' focus group discussions conducted after the PDI to examine and confirm the dependability of teachers' views collected during the post-intervention focus group discussions and reflective notes. The students reported that their teachers had recently started using learner-centred teaching methods. One student claimed that:

> Science teachers are using learner-centred methods but not all science teachers. The new mathematics teacher and physics teacher are not using learner-centred teaching methods but the biology and chemistry teachers are. Will you advise them to use leaner-centred teaching methods because when they use them we [students] understand the subjects easily and in a very short time ... yah it is a good method. (Hadija, Form 1 student from Tlawi secondary - phase 2 focus group discussions)

A similar claim was made by Kasim.

> No, not all teachers are using learner-centred teaching methods as it depends on the teacher's decision because the teacher must initiate the use of learner-centred methods. If a teacher is not interested in using learner-centred methods,

> he or she will not ask you to work in groups. Also it depends on the subject. For example, for subjects such as English, Kiswahili and history, teachers are not using learner-centred methods. (Kasim, Form 3 student from Hewasi secondary school - phase 2 focus group discussions).

Another student also commented that “physics and chemistry teachers are using participatory teaching methods. The physics teacher usually likes using more participatory teaching methods than the chemistry teacher. He started when we were in Form 1 and I like his teaching” (Rose, Form 1 student from Nungu secondary school - phase 2 focus group discussions).

The students claimed that learner-centred teaching methods are a valuable teaching approach because they understand more when classroom teaching is learner-centred.

> I like very much learner-centred teaching methods because you get the opportunity to share your ideas with other students in the classroom. For example if don’t understand a concept in the class when the teacher is teaching you can share your ideas with friends and you will understand and learn a concept which you didn’t understand before. (Philomena, Form 2 student from Hewasi secondary school - phase 2 focus group discussions)

Another student also claimed that the learner-centred teaching method makes them active learners in the classroom as it allows them to share knowledge with friends.

> Learner-centred teaching makes you intellectually active; it removes loneliness and fear during teaching and learning in the classroom. For example, if you don’t have any idea about the topic and if you ask your friends who understand such an idea you will also understand and this helps me to learn easily. (Ghaghara, Form 3 student from Hewasi secondary - phase 2 focus group discussions)

A student also commented that learner-centred teaching methods bring students closer to their teachers and help to improve students' attentiveness in the lesson. Samwel commented that:

> You know sometimes when the teacher is teaching and he [she] is not interacting with the class you might be physically in the class but your mind is out of the class thinking about something else. Therefore, when teaching is using learner-centred it helps to bring you back into the classroom and concentrate on what the teacher is teaching. It means it helps student to forget some family problems and concentrate on learning during the learner-centred group work. (Samwel, Form 3 student from Nungu secondary school - phase 2 focus group discussions)

Interestingly, one student commented that the learner-centred approach helps to reduce misconception(s) during teaching. Gisa claimed that:

> Learner-centred [teaching] method is a good method because it helps students to understand the concept easily, and you can use your friends' ideas to correct your misconceptions. You get the truth about what you learning from your friends' contributions. (Gisa, form 1 student from Tlawi secondary school - phase 2 focus group discussions)

Fatma also commented that when teaching is learner-centred there is deep learning.

> Participatory [learner-centred] teaching methods help to build students' confidence in the subject, because when everyone in the classroom chip-in what she [he] knows you get new ideas from one or two people [students] and that will add to the little you know so that you will deeply understand the concept the teacher is teaching. (Fatma, Form 1 student from Katani secondary school-phase 2 focus group discussions)

These students' views suggest that the professional development had positive impact on teachers' classroom practices as teachers began adopting learner-centred teaching practices. Students were convinced that the use of learner-centred teaching helped to promote their deep learning and they understood the impact of using learner-centred teaching methods on their learning.

5.6 Establishment of teachers' professional learning communities

During the PDI the licensed science teachers were encouraged to share the knowledge and skills they had gained with other science teachers in their schools. The intention of introducing school-based sharing of new knowledge was to develop a PLC of teachers in their schools. The licensed science teachers reported that a culture of sharing classroom teaching and learning materials was now developing in their schools and teachers were positive about working together as a learning community. For example Manimo claimed that:

> The concept of team teaching was very helpful for my classes because I received some help from another teacher from the neighbouring school. I shared my teaching notes and we discussed how to teach some science topics. I once invited my friend from another school to clarify some mathematics concepts. (Manimo, phase 2 post-intervention reflection notes)

In a similar vein Safari revealed that he shared examination preparation and the teaching of difficult topics with another teacher in his department. Safari said:

> Working as a professional learning community is helpful because I was able to share examination preparation with my friend who is teaching science. He also helped me to understand some difficult topics like the rate of reaction in the chemistry syllabus. You know sometimes there are some unseen challenges that you cannot see yourself but if you get tips from other teachers on how to teach a

> certain topic, you can improve your teaching and students' learning too. (Safari, phase 2 post-intervention reflection notes)

Qwary also reported that he shared his teaching with a geography teacher. He describes that:

> Of course this professional development programme helped me a lot. I like working as a team, and in some lessons I asked for other teachers to help... for example, I asked a geography teacher to teach the physics subject topic of Geophysics. (Qwary, phase 2 post-intervention reflection notes)

In addition, Qwary also made a similar comment during the workshop. He reported that:

> Having a professional learning community of teachers transforms teachers' classroom practice; it helps to close the knowledge gap when teaching some science concepts, especially in the subject content and working in a team improves teachers' pedagogical content knowledge and students' learning outcome. (Qwary, phase 2 workshop reflection notes)

Pombe also reported that working in a team had simplified her lesson preparation. She reiterated that "we shared experiences with other teachers, in particular the preparation of science practical lessons as a team of teachers, which was helpful and reduced the hassles of planning science practicals" (Pombe, phase 2 post-intervention reflection notes).

Another teacher explained how working as a community of learners helped to build trust among teachers because every contribution was considered important.

> Working as a community of teachers had a great impact on my practice because it has developed the spirit of collaborative learning where everyone's ideas are equally valued. This has eradicated some teachers' superiority and inferiority

> complexes because we are all equal during the discussion. (Qwary, phase 2 post-intervention reflection notes)

These teachers' views suggest that the PDI had a positive impact on teachers' teaching practices as teachers adopted a culture of sharing knowledge to improve their teaching. Also, their views indicated that the teachers valued the culture of working together as professional learners.

5.7 Perceived impediments to implementing the skills gained from PDI

Licensed science teachers reported on some impediments they had faced during the implementation of new skills gained from the PDI. They identified the lack of follow-up training as one of the barriers to the implementation of new teaching skills. Manimo commented that:

> I think the lack of a follow-up seminar after the intervention is a major weakness of the programme because sometimes we get stuck and there is no-one to ask in the school, particularly when you need to explain a new concept to someone who had not attended the workshop. (Manimo, phase 2 post-intervention reflective notes)

A similar concern was shared by Tiita that the "lack of follow-up seminars and workshops for science teachers is a challenge when sharing new knowledge with other teachers" (Tiita, phase 2 post-intervention reflective notes). Qwary felt that licensed science teachers needed on-going support from the facilitator to make the intervention sustainable. He commented that "if there is a difficult concept that needs elaboration then the facilitator must be easily available. Therefore, in order to make the skills sustainable there should be a regular visit by the facilitator" (Qwary, phase 2 focus group discussion).

Other licensed science teachers commented that the lack of teaching materials and laboratory supplies was affecting the implementation of new skills. Pombe reported that “the common challenge is the shortage of reference books and important teaching models, such as ear, eye and kidney …. also the absence of a teacher resource centre and science laboratory apparatus” (Pombe, phase 2 post-intervention reflective notes). Safari also reported that “insufficient teaching materials, e.g. some specimens for teaching biology practicals, laboratory apparatus, even some books in science subjects such as Biology and chemistry are not available” (Safari, phase 2 post-intervention reflective notes). Of significance were comments by Manimo who felt that because this intervention involved only a few teachers and schools it would have little impact on the Tanzanian education system.

> The weakness is that very few of us have attended this professional development training, and so it is unlikely that this workshop will have a major impact on all community secondary schools in the country. I suggest that this programme should be expanded so that many teachers are involved all over the country, because when we present this issue to other teachers there are a lot of questions from our colleagues about professional learning communities of teachers. (Manimo, post-intervention focus group discussion)

The views expressed suggest that the participants experienced some difficulties in implementing the new skills acquired during the PDI. Also they pointed out that professional learning intervention(s) require school-based expert support over the long term.

5.8 Teachers’ classroom practices after the PDI

Licensed science teachers’ classroom teaching practices were observed eight months after the PDI was implemented to examine whether or not their classroom practices had changed because of the intervention. Five out of six the licensed science teachers, who participated in the professional development workshop, were observed. One teacher was not available for the observation because of family issues. The classroom observations focused on how licensed teachers were teaching their lessons, on teacher-student interactions, student-student interactions during the lesson and teachers' growth in PCK that showed in their classroom practice. Teachers' practices that indicated growth in PCK were shown by italicising specific components of PCK in brackets for each lesson observed. During the second phase of data collection the teachers developed trust in the researcher and some allowed photos of their classroom teaching to be taken. Narratives of selected individual lessons are presented in the next sub-section as a representative sample of the findings.

5.8.1 Pombe's classroom teaching practices

Lesson one. During the weekend the researcher visited the school academic teacher and copied the timetable of classes taught by the teachers involved in this study. The researcher arrived in the morning at Tlawi secondary school five minutes before the start of Pombe's class. The researcher met Pombe in her office as she was finalising her lesson preparation and asked if her lesson could be observed today. Pombe was happy and she welcomed the researcher into her class. She told the researcher that they were studying photosynthesis in different plants. The researcher joined the class with his research notebook and camera and observed Pombe teaching the class. Pombe's lesson involved outdoor activities around the school garden teaching photosynthesis, using plants that were available in the school environment. Pombe selected a plant (Euphorbia tirucalli) and asked the students if they knew the name of that plant (Figure 3).

They mentioned different local names according to their mother tongue. However, she guided the students and described that the plant belongs to the family called 'Eupphorbiacea', the kingdom Plantae and the phylum Angiosperm and it mainly uses the stem for photosynthesis *(knowledge of learners' understanding)*. She described other examples of plants that do not have leaves but have a green stem (Figure 4), and she discussed with her students how plants use the stem for photosynthesis.

Figure 3: *Pombe showing Euphorbia Tirucalli species*

Figure 4: *Pombe showing students Cereus Hidmannianus a plant from the Cactus family that uses its stem for photosynthesis*

The students' discussion was enthusiastic, and there was a lot of exchange of ideas between the students themselves and sometimes there was a lot of language code-switching between Kiswahili, local languages and English during the discussion. Discussion focused on the photosynthesis process of different plants such as those with green leaves, without leaves or those which use the stem (Figure 4) for photosynthesis in coloured (Figures 5 & 6) plants.

Figure 5: *Pombe stands in front of green and yellow leaved plant*

Figure 6: *Pombe examining plant with green and yellow patches*

This lesson was interactive and contextualized for the students in the local environment. She utilized the school environment as a biology laboratory. The teacher guided the students in their discussion by visiting a particular plant. They were curious and were seen looking at it and discussing the different features used by plants (Figures 7 & 8) during photosynthesis.

The teacher asked 16 formative questions (e.g., What is the role of spines in cactus? Can you explain why most plants that use stems do not have leaves? Where do cactus plants store water? What is the function of areoles in cactus plants? Give examples of plants that use the stem for photosynthesis? What are the end products of photosynthesis in plants?) *(Knowledge of assessment)*.

Figure 7: *Students discussing cactus, and in the fore ground is a plant with both green and yellow leaves*

Figure 8: *Students listening and observing*

She in turn was asked eight questions by the students, mostly about the 'milk sap or latex' produced by the Euphorbiaceae plant family. Examples of questions were: What is the name of the milky sap produced by this plant? Can you explain why this milky sap causes irritation or burns when it comes into contact with the skin and eyes? What is the function of milk sap in the plant? The students asked these questions in Kiswahili.

These questions were hard for Pombe to answer because she did not expect them as her lesson focus was on photosynthesis. She responded by telling her students that the researcher is a biology teacher and could respond to some of their questions. The researcher responded to Pombe's request by asking the students to discuss the questions in their groups and in the next period they were asked to do a presentation of their ideas. Their teachers would help them to give the answers to these questions. Pombe then added that "we will discuss these questions next time but today let us focus on photosynthesis". Pombe taught her lesson by exploring all the opportunities that were available around the school and describing the photosynthesis of different plants and their adoptive features *(knowledge of science curriculum)*. The lesson was interactive and friendly and the students enjoyed talking to the teacher and fellow students. Pombe summarised the lesson and reminded the students that she will discuss those unanswered questions in the next period.

After the lesson Pombe asked if the researcher's laptop was connected to the Internet, so that she could look at those students' questions because in her school there were no reference books and those concepts were not covered in the textbook she was using. The researcher was also interested in finding out the answers to those students' questions. He logged on to the internet and used Google to find the words 'milk sap' and then 'latex.' The researcher and teacher read about these concepts together and Pombe made some notes for her next lesson. Pombe commented that "if every teacher had access to the Internet and other teaching resources, teaching would be easy. If you had not been here today I would have found it difficult to respond to some of those questions. You see because you have a laptop and modem it is easy to refer to difficult concepts". There was a significant improvement in Pombe's teaching practices from pre-intervention observation, in particular her ability to develop an interactive lesson using the local environment to aid her teaching. Her student-student interactions had also improved, in particular the ability to ask challenging questions. Pombe did not have a lesson plan, but had prepared lesson notes and she was also using the biology book to refer to some concepts while she was teaching. The mode of instruction and design of the lesson suggests that Pombe's orientation towards teaching science has changed from that of lecturing students to facilitating students' learning. Also Pombe's classroom teaching practices indicated significant growth in the PCK components of knowledge of instructional strategies and knowledge of students' understanding.

Lesson two. Pombe's second lesson was pre-planned and she was aware that the lesson would be observed. The lesson was about testing for the presence of starch in plant leaves that had accumulated because of photosynthesis. Pombe used two different types of plant leaves, one green and the other yellow *(knowledge of science curriculum)*. She prepared a demonstration by setting up four tables surrounded by approximately 15 students. Each table displayed apparatus including a spirit burner, spirit liquid, test-tube, triple stand, alcohol, iodine solution, forceps and a conical flask (Figure 9). Pombe introduced the lesson by giving students different leaves. She asked them to point out the major differences between the two leaf samples and predict what would happen after boiling them in water and adding iodine to the boiled leaves *(knowledge of assessment).*

Figure 9: *Teacher demonstrating the starch test in leaves*

The boiling of leaves took almost 15 minutes and then the teacher started testing for the presence of starch while the students watched. The leaves were tested for the presence of starch and they changed to blue-black on testing with the iodine (Figure 10) *(knowledge of instructional strategies).* The students observed and recorded the predicted changes individually (the leaves will change to the following colours: blue, blue-black, black) and demonstration results were corrected after the lesson through guidance from the teacher.

Figure 10: *Students observing the change in colour of boiled leaves after adding iodine in photosynthesis investigation*

The demonstration was successful in that the test indicated the presence of starch by a change of colour (blue-black colour) and the students become curious and started asking questions like: why is iodine used for testing starch and not glucose? Why is alcohol added to the boiled leaves?

Pombe responded to these questions by asking other students to give the answers, which she summarised on the blackboard. After the results were obtained the teacher summarised the lesson and she was asked again by the students ‘why have some parts of the leaves not changed completely’? The teacher responded that some parts have not been well boiled or contain less starch because of inadequate photosynthesis. The lesson was interactive and students were curious. The teacher asked eight formative assessment questions: such as, why is it necessary to boil leaves? Is testing for the presence of starch to show that photosynthesis happened in plants? What colour changes are you expecting to see in the boiled leaves? In addition, she was asked four questions in return during this lesson *(knowledge of assessment)*. Pombe’s classroom practices demonstrated significant growth in the PCK component of knowledge of instructional strategies. While going into her office after the lesson Pombe claimed that “I tried this experiment three times to make sure it would work in the class”. In this experiment the teacher did not have any protective gear such as goggles and gloves. When the researcher asked why she did not use goggles to protect herself she responded that “eye protective gadgets are not available in the school laboratory”. Pombe had prepared the lesson plan and the specific objectives were written using action verbs. However, the lesson plan booklet template did not have the previous lesson plans. Some pages had been skipped.

5.8.2 Manimo’s classroom teaching practices

Lesson one. Manimo was not aware in advance that the researcher would come to observe his lesson. The researcher arrived three minutes before the start of the lesson and asked Manimo if his lesson could be observed. Manimo allowed the researcher to observe his class. The lesson was about mathematics and the topic was ‘unit of time’. He started the lesson by checking some students’ exercise books to see whether they had done their homework. He then asked the class monitor to collect each student's homework and take the exercise books to his office for marking after the period. Manimo then grouped his students into 12 groups, each group with approximately 6-7 students (Figure 11). The topic title 'unit of time' was copied on to the blackboard as well as the lesson objectives. The main objective of the lesson was how to write the time given in numbers in words. He then introduced the lesson by writing sample questions (8.40 am, 9.45pm, 11.02 am and 12.30 pm) on the blackboard *(knowledge of instructional strategies)*. The students in their groups started discussing and providing responses to the question written on the blackboard verbally and the teacher copied these students' correct answers on the blackboard and the students copied the answers in their exercise books.

Figure 11: *Manimo looking at students' groups' task*

Manimo added other examples and asked students to write the answers in words in their exercise books. Some of the examples were: (a) 10.00 am (b) 11.00 am, and c) 11.05 pm. While the students were doing the assignment Manimo moved around each group to look at their work. The students appeared to be enjoying the lesson and raised their hands asking the teacher to visit their group because they had finished the work. Manimo was unable to visit them all. The group work took almost 15 minutes. He then invited some students to come to the front of the class and write the answers from their groups. After the students had presented the answers, Manimo summarized the lesson by asking the students if each answer was correct and the students chorused 'yes'. Once the lesson was summarised the students were given a take-home assignment. Manimo asked about seven formative assessment questions and he was asked three questions by students.

Manimo's classroom practices indicated a more learner-centred approach because he provided students with an opportunity to write answers on the blackboard (*knowledge of learners understanding*). Students were seen to be participating enthusiastically in the learning process. Student-student interactions had also improved, though they mostly talked in Kiswahili and wrote answers in English. Manimo also switched between English and Kiswahili during his teaching, particularly when elaborating during his lesson. Manimo did not use a lesson plan template to prepare his lesson, but instead had prepared lesson notes.

Lesson two. This lesson on logarithms was for Form 2 students and had been planned in advance. Manimo introduced his lesson by revising the previous lesson. He then moved into the new lesson by explaining to the students what they would achieve by the end of the lesson. The lesson had one main objective, which was finding the logarithm of a number using Four Figure Logarithm Tables. Manimo formed six groups of students, each with approximately 6-8 students, and distributed one set of the Four Figure Logarithm Tables to each group (Figure 12).

Figure 12: *Students in- group discussion during the lesson*

Manimo reminded his students that the school did not have enough copies of the Four Figure Logarithm Tables for all of them and so they had to share. Then he wrote an example (find the logarithm of 347) on the blackboard and guided the whole class students' discussion on how to solve the two logarithm questions on the blackboard. He then copied three questions ($1. \log_{10} 568$, $2. \log_{10} 5685$, $3. \log_{10} 6725$) on the blackboard for students to solve in their groups. Students worked together in their groups solving the problems and recording the answers in their notebooks.

Thereafter, Manimo selected a student from some groups to show how his/her group had solved the question on the blackboard while the other students watched (*knowledge of instructional strategy*). After each question the teacher asked the whole class if the solution to the question was correct and they chorused 'yes' or 'no'. Then Manimo repeated the procedure on the blackboard.

Manimo explored different logarithms questions using two, three and four digit numbers (*knowledge of science curriculum*). The lesson took almost 80 minutes as finding logarithm numbers was a challenging activity for the students. They were active in their learning and some were seen asking the teacher for help during the lesson. The teacher also moved around to see what the students were doing, showing them how to find logarithm numbers using the 'Logarithm Tables' where students needed support. Manimo asked eight formative assessment questions during the lesson and he was asked three questions. The lesson was summarised and he gave out two questions for the students' homework. The lesson was interactive and students fully participated during the lesson with visible student-student interaction. The challenge during this lesson was the shortage of Four Figure Logarithm Tables, which meant that the groups were large, consisting of more than six students per group. As a consequence the lesson was quite long. Also, Manimo appeared more organized than the previously observed lesson before the PDI. Manimo's classroom practices indicated improvement, in particular the involvement of students during the teaching and learning process.

5.8.3 Tiita's classroom teaching practices

Lesson one. Tiita's lesson observation was pre-planned and he was aware that the researcher was coming two days earlier. He started the lesson by revising the previous lesson and looking at the students' exercise books. The lesson observed was physics for Form 2A and the topic was 'simple machines' (Figure 13). The lesson was well organized. Tiita brought different samples of simple machines to facilitate his teaching. The simple machines used to aid his teaching were those commonly found in the students' environment such as a hammer, spanner, screw driver and others (Figure 14). Tiita outlined the objectives of the 80-minute lesson on the blackboard. These objectives were at the end of the session the students will be able to: 1) describe the difference between simple and complex machines by giving examples, 2). Define load, effort, mechanical advantage, velocity ratio and efficiency of machines, 3). Describe the application of simple machines in the home environment *(Knowledge of instruction strategies)*. Tiita started the lesson by asking students in their groups to discuss (teacher demonstrated PCK growth) and provide a definition of a 'simple machine', give examples of simple machines, and a definition of load, effort and mechanical advantage, velocity ratio and efficiency of machines.

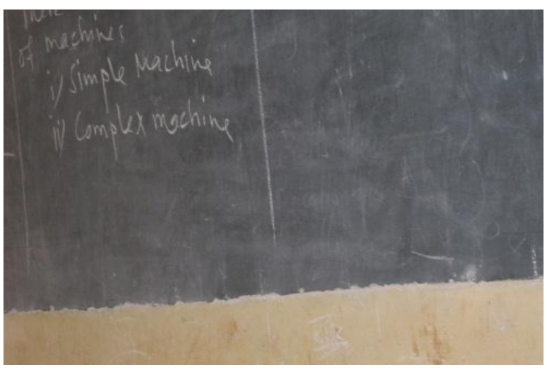

Figure 13: *Tiita's lesson objectives stating what students are going to learn in lesson*

Figure 14: *Some teaching aids used during Tiita's the lesson*

Then he arranged the students in nine groups with approximately 5-6 students per group and each was given a few samples of simple machines. Each group was given the task of identifying the features of simple machines and their applications in daily life. The groups took almost 15 minutes to discuss and complete the task while the teacher went round looking at the groups' work *(knowledge of learners understanding).* He picked one student from each group to present to the class what they had discussed. Some presenters were shy while others spoke confidently. A summary of the answers was collated on the blackboard.

The students used both English and Kiswahili for their presentation. Tiita then summarized the whole lesson step-by-step according to the lesson objectives. At the end of the lesson he summarised the lesson by asking the students to identify examples of simple machines, and differentiate simple machines from complex machines. The lesson was interactive as it involved students in demonstrating how simple machines work (Figure 15).

Figure 15: *Students demonstrating how some simple machines work*

The teacher finally copied a question on the board that required the students to calculate the velocity ratio and mechanical advantage of the pulley. Tiita asked 14 formative questions (e.g., What is a simple machine? Why is a hammer considered a simple machine? Is the generator a simple machine? Why is a generator not a simple machine?) during the lesson and he was asked five questions by the students *(knowledge of assessment).* Tiita’s teaching practices observed in this lesson suggest that his pedagogy had changed, in particular the use of learner-centred instruction. The students were seen participating in the discussion despite the difficulty of conversing in English. Tiita had prepared the lesson plan with well-constructed student learning outcomes; however, the examination of his lesson plan template indicated that he had skipped some pages. On asking the reasons for skipping some pages of his lesson plan template, Tiita responded that “I was busy last week because I was the teacher on duty and I didn’t have time to prepare my lesson”.

Tiita lesson 2. Tiita’s second lesson was a continuation of the simple machine lesson given to Form 2B and specifically focused on classes of levers. Tiita started the lesson by asking the students to identify examples of simple machines and to explain the difference between a simple and complex machine. Tiita called students by name when asking questions. He used different simple machines to demonstrate the types of levers, such as pulling out a nail using a claw hammer, a clothes peg, a pair of scissors, pliers, crowbar, wheelbarrow, spade, forceps, spanner, and a bottle opener to describe the classes of levers. The students were asked to organize various instruments into the first, second and third classes of lever. The class was very active and the students appeared enthusiastic with the exercise because there was lot of debate before agreeing on a particular class of lever. The teacher guided the students’ discussion first by asking them to identify the position of effort, fulcrum and load for each class of lever *(knowledge of learners understanding)*. The discussion was very animated as there was vigorous debate about the third class of levers. The third class of levers generated a lot of debate when the teacher sketched a diagram on the blackboard of a fisherman fishing in the pond using a fishing rod with a hook holding the fish. The position of effort, fulcrum and load was not clear to the students and they asked six questions about it. Tiita elaborated on the concept illustrated in the diagram by using the blackboard duster, ruler and desk (Figures 16 & 17) *(knowledge of science curriculum).*

He explained that the effort (his arm) was between the effort and the fulcrum and this explanation made the students more confused. He then provided another example of a spade to describe the third class of lever *(knowledge of instructional strategies)*. The class was very attentive watching the demonstration and some students were asked to identify the position of the fulcrum, effort and load for each class of lever.

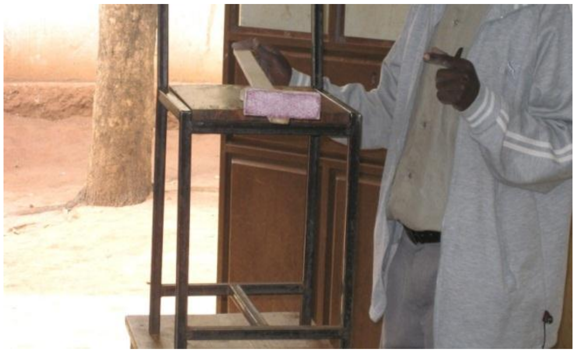

Figure 16: *Tiita demonstrating third class lever*

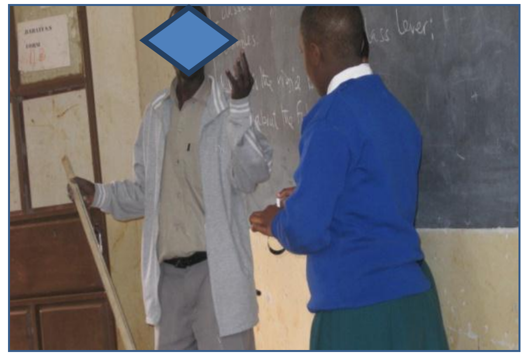

Figure 17: *Tiita discussing the third class lever with student*

The lesson appeared to engage students and they were was seen sharing ideas in their discussion. Tiita did not write a summary of the lesson on the blackboard because most of his teaching time was used discussing the classes of levers. Tiita asked 13 formative assessment questions (e.g., Describe the characteristics of a first class lever. Mention the characteristics of second class levers. Describe the characteristics of third class levers. Give reasons why tongs are considered a third class lever.) *(Knowledge of assessment).* Tiita was asked six questions by the students.

5.8.4 Qwary's classroom teaching practices

Lesson one. Qwary was unaware that the researcher would be present for the lesson. The researcher arrived seven minutes before Qwary's class and asked him if his classroom teaching could be observed. Qwary was happy for his teaching to be observed. He had planned to teach Form 3 mathematics and the topic was 'linear function'. The class had 71 students. After arriving in the classroom Qwary started the lesson by checking the students' notebooks to see if they had finished their last week's homework. Before the start of the lesson the teacher asked if any student would like to solve an assignment question on the blackboard (*Knowledge of learners' understanding*). The students' last homework questions were from mathematics sub-topic 'Domain and Range'. Qwary appointed one student to solve the question $g(x) = x - 1$ on the blackboard. The student silently solved this question but Qwary requested him to speak louder so the other students could follow what he was doing *(Knowledge of instructional strategies)*. The student tried to speak a few words but he was shy although he solved the question correctly.

Qwary introduced the new lesson by asking the students to define ‘linear function’. However, no student responded. After two minutes of silence he reminded the students about the mathematics topic ‘coordinates’ in Form 1 mathematics to describe the concept of linear function *(knowledge of science curriculum)*. He demonstrated the linear equation concept using two coordinates A (4, 1) and B (7, 4). Then he calculated the gradient from these coordinates, after which he asked the students if they could now calculate the equation of a straight line using the given coordinates and gradient. Instead of giving the students the opportunity to calculate the linear equation he did the calculation and obtained the equation (y = $\frac{5x}{3} + \frac{1}{3}$) for his students. He converted this equation into an equation of the line y = Mx + C. After he had finished solving the question he copied the definition of a linear function on to the backboard, that is, the “gradient equation where M is the gradient or slope and C is the y intercept”.

Then he copied another question on to the blackboard “Find the linear function f(x), if the gradient of the line is -2 and f(x) =3) draw it as a graph”, and asked the students in pairs to solve the question. Two minutes were given for students to calculate the equation of linear function but this was not adequate time. A few students managed to solve it, but many were seen to ask help from other students during the lesson. Qwary then started looking at individual students’ work to see what they had done and started helping them. After looking at six students’ exercise books he decided to solve the question on the blackboard for the whole class to observe. After solving the question he copied three questions on to the blackboard as an assignment for the students. The students were seen going around asking their fellow students to elaborate on the previous question solved on the blackboard. Qwary asked six formative assessment questions during the lesson and he was asked three questions by the students. Qwary was mostly using the whole class instruction approach. However, student-student interaction was more obvious than before the PDI and teacher-student interaction had also increased. In the office after the lesson Qwary commented to the researcher that is “difficult to teach Form 3 using the learner-centred approach because the class is too big… there is a shortage of rooms in this school”. Qwary had prepared teaching notes but the lesson plan was not available. When the researcher asked if he had a lesson plan for this lesson, he responded “I have not yet finished preparing this week as I was busy... but I have prepared classroom teaching notes”. Qwary linked his lesson to students’ previous knowledge about coordinates (*Knowledge of learners’ understanding*).

Lesson two. Qwary’s second lesson was pre-planned and he was aware of the researcher’s visit. Qwary prepared a physics lesson for Form 1 students and the sub-topic was ‘warning signs’ used in a physics laboratory. The lesson was well organized although the class was big with a total of 81 students. Also there were not enough chairs and desks and so students shared desks. About five students stood during the lesson due to the absence of desks. The teacher started the lesson by revising the previous lesson and checking a few students’ exercise books for about five minutes *(Knowledge of learners’ understanding).* He then introduced the new lesson by writing the objectives of the lesson on the blackboard that would be achieved at the end of the lesson. Qwary asked the students to describe what they understand by ‘warning sign’ and summarised students’ responses on the blackboard. He explored different places where warning signs or symbols are used in school and the school laboratory (*knowledge of instructional strategies*). He then distributed different bottles and printed material with warning signs on particular bottles used to keep chemistry reagents and pesticides, plastic packets and used maize/corn pesticides (*knowledge of science curriculum*). The students were very active looking at the warning signs that were glued on the labels on the bottles. The labels and printed warning symbols were checked by one after another in the class and when complete he asked some students to come to the front of the class and draw a warning sign on the blackboard (*knowledge of instructional strategies*). They were also to explain the meaning of the sign to the class verbally. Different warning signs/symbols were drawn on the blackboard, including the sign for flammable substances, harmful substances, poisonous substances, and corrosive substances, on food or drink labels, electrical hazard labels, high radiation label substances, toxic substances, explosive substances, oxidizing, environmentally hazardous, chemical and harmful or irritant substances. Some students were seen correcting the spelling mistakes of fellow students on the blackboard. The lesson was well planned and despite the large number of students in the class they were seen to be interacting. The pre-planned activities for students encouraged the lesson to be interactive. Qwary asked 13 formative assessment questions during the lesson and was asked five questions (*knowledge of assessment*). The teacher's classroom practices were evidence of significant growth in his PCK *(knowledge of science curriculum, knowledge of learners' understanding, and knowledge of instructional strategies).* During this lesson student-student interaction and teacher-student interaction was very apparent. The students took a participatory role and were part of classroom instruction. After the lesson on our way to the office Qwary reported that he had borrowed some of those bottles and chemicals from the neighbouring school and veterinary shop. He was also very happy with his students and commented that "Form 1 students are very active in the class because they want to enquire more when you are teaching… you know I introduced them to learner-centred methods when they were enrolled". The researcher's classroom observation suggests that the teacher's classroom practices had changed and he was able to guide students to learn more deeply rather than just cover the content.

5.8.5 Safari's classroom teaching practices

Lesson one. Safari's lesson was pre-planned and he was aware that the lesson was going to be observed. Safari had prepared a chemistry lesson for Form 1 students and his class had 76 students. He started the lesson by revising the previous lesson about the laboratory and laboratory rules. The teacher asked different students to state the laboratory rules. The students were active in their responses stating the laboratory rules and the teacher summarised their responses on the blackboard. Safari appointed students from different corners of the classroom to answer the questions, which helped the introduction of the lesson to be interactive (*knowledge of learners' understanding*). After revising the previous lesson he introduced the new lesson by writing on the blackboard the sub-topic "source of heat in the chemistry laboratory', and then outlined the lesson objectives to be covered by the end of this period. Safari started his lesson by exploring students' prior knowledge about the source of heat by asking them to mention different heat sources that are used in their homes (*knowledge of learners' understanding*). Then he asked them to mention heat sources that were used in the school environment and laboratory. To help students understand, he presented examples of local burners, such as kerosene burner, spirit burner, charcoal burner and Bunsen burner. The teacher summarised all the students' responses on the blackboard and then led his students in a discussion of different types of flames produced by the Bunsen burner, which is the most commonly used heat source in the school laboratory. Unfortunately, the school did not have a laboratory or gas for lighting the Bunsen burner to demonstrate luminous and non-luminous flames produced by the Bunsen burner. However, the teacher drew a sketch of the Bunsen burner on the blackboard and asked the students to label the parts. They were unable to label the parts of Bunsen burner, except for two students who had a textbook and who raised their hands. The teacher labelled the parts and described the features of each part. Safari then asked his students to copy the sketch into their exercise books while he moved around looking at what the students were doing. The teacher then wrote a summary of the lesson on the blackboard and the assignment for students, who were seen discussing the assignment while the teacher was checking their exercise books. Despite the large class size, the teacher involved his students in the lesson. He asked nine formative assessment questions and he was asked six questions *(Knowledge of assessment)*. The teacher had prepared teaching notes a student assignment. His teaching had changed substantially compared with the lessons observed before the PDI. He asked more questions, and guided the students to explore the lesson using their local environment. Also he had demonstrated the use learner-centred instruction during his teaching.

Lesson two. Although Safari indicated that the second lesson observation could be done the following Monday, Safari did not turn up on Monday as agreed on Friday. He had some family issues and the researcher was unable to observe his second lesson.

5.9. Evidence of improved licensed science PCK after professional development intervention

As reported in the lesson narrations (section 5.8.1-5) teachers' classroom practice indicated more use of formative assessment questions than the lesson observed before the PDI (See Table 6). This finding suggests there is basic improvement in licensed science teachers PCK from rare interactive teaching episodes to more active involvement of learners during the classroom instruction. This shift suggests significant growth of their knowledge base of teaching as a result of PDI. More importantly, classroom observation practices 8 months after the intervention indicated that licensed science teachers were using the new knowledge and skills gained during the PDI in the teaching of their lessons, which suggests the sustained impact of the intervention. Likewise, the classroom practices of the lessons that were observed, where the licensed science teachers were not sure in advance if their lesson would be observed, also indicated improved practice and sustained PCK growth.

Table 6: ***Summary of questions asked by teachers and students in each lesson observed***

		Teachers names and lessons observed												
		Manimo		Tiita		Sungura		Pombe		safari		Qwary		
Subjects observed		Mathematics	Physics	Physics	Chemistry	Physics	Biology	Biology	Biology	Chemistry	Biology	Physics	Biology	Chemistry
Questions asked by the teacher	before	2	4	6	2	0	3	4	0	4	1	1	0	3
	After	15	-[16]	27	-	-	-	16	8	9	-	19	-	
Question asked by students	before	0	0	0	0	1	0	0	0	1	0	1	1	0
	After	7	-	11	-	-	-	8	4	6	-	8	-	-

Source: Classroom observation

[16] Lesson was not observed

Likewise, licensed science teachers' classroom planning, in particular schemes of work indicated their lesson plans showed sustained improvement in their PCK from limited or weak to strong PCK for inquiry-based teaching (Table 7). Comparison of extracts from the licensed science teachers planning conducted before and after the PDI using PCK rubrics (Gardner & New-Gesssome, 2011; E. Lee et al., 2007; Park et al., 2011) indicated that the teachers' lesson planning before the PDI possessed many features of teachers with weak PCK and lesson planning after PDI contained more features of teachers with basic or strong PCK for teaching for inquiry learning (see Table 7).

Table 7*: Changes in teachers' planning reflecting movement from weak/ limited to stronger PCK*

Topic	Teacher's activities before PDI (learning outcomes)	Teacher's activities after PDI (learning outcomes)
Introduction to biology - (Pombe, Biology form I scheme of work extract)	-Define the term biology -Describe importance of learning biology	-To use students' responses to make clarification on basic biological concepts, terminologies how to apply biology knowledge in their surroundings -To guide students to summarize their responses and make conclusion -In groups students to discuss biological concepts such as living things, life cell etc.
Biology laboratory - (Pombe, FI Biology scheme of work extract)	-To describe the structure of biology laboratory -List common laboratory apparatus in the school laboratory	-To organise students study visit to other school with biology and chemistry laboratory and study the laboratory setting -In groups students to observe and discuss laboratory chemicals and apparatus
Exponents and radicals - (Manimo, Mathematics scheme work extract)	-Discuss laws of exponents by wall chart -Derive the law of exponents	-To guide students to derive laws of exponents -Students in groups discuss the applications of exponents' laws.

Binary operation - (Manimo, Mathematics scheme work extract)	Demonstrate how to perform binary operation	-Students in groups to do presentation of binary operation.
Radioactivity - (Qwary, Physics scheme work extract)	-Define the radio-activity -Demonstrate to students to students how to determine half-life of radio-isotopes	-Students in groups to discuss the meaning, calculate the half-life of radio-isotopes -Students' to present the application of radio-isotopes.
Kingdom Plantae (division Coniferophyta) - (Safari, Biology scheme of work extract)	-Discus with students distinctive features of plants under division Coniferophyta	-Students to collect and observe various plants around school environment and identify the plants belongs to Coniferophyta -Students to present the main distinctive features of division Coniferophyta.

Source: Extracts' taken from teachers' schemes of work

This finding therefore suggests that the teachers' planning practice after the intervention reflected more inclination towards inquiry-based teaching. Most of the activities identified in teachers schemes of work before intervention indicated that teachers has been using teacher-centred teaching strategies such as defining, describing, listing, demonstrating, which in principle are not participatory teaching strategies. While the post intervention teachers' activities indicated that they have been utilizing the learner-centred instruction. These teachers' activities in fact are not activities but suggest being learning outcomes.

5.10 Evaluation of examinations prepared by licensed science teachers after PDI

The study also examined whether or not the quality of tests and examinations prepared by the licensed science teachers after the PDI had improved, especially in terms of testing the higher levels of Bloom's knowledge categories. The findings suggest that there was little improvement in their ability to develop the higher level test items of Bloom's knowledge categories (Table 8). Most of the examinations were found to be testing the lower levels of Bloom's knowledge categories with a few test items aimed at the higher levels of Bloom's knowledge categories. These results were similar to the examinations prepared before the PDI. The post-intervention test items also showed that the licensed science teachers still had difficulty constructing test items as some of their test items were unclear and contained English grammatical errors. Common mistakes included the use of wrong English words and unclear stem statements in test items. Below are some examples of examination items that were found unclear or confusing.

Question 1 (i). The small box which simple medicine, chemicals and instruments for first aid is called (A) First aid kit (B) first aid (C) first aid component (D) first aid provider. (Pombe, phase 2 form 2 Biology

Table 8: *Test items testing different Bloom's knowledge categories*

Names of teachers'	subjects	Number of test items	Categories of knowledge levels tested by proportion (%)					
			Knowledge	compression	application	Analysis	synthesis	Evaluation
Pombe	Biology[17]	54	57	27	6	6	2	2
	Biology[18]	25	64	4	4	20	4	4
Safari	Chemistry [19]	47	66	9	8	4	9	4
	Physics[20]	48	77	2	17	2	2	-[21]
Qwary	Biology[22]	38	82	3	3	5	3	4
	Biology[23]	32	63	6	22	4	3	2
Manimo	Physics[24]	41	73	12	10	5	-	-
Tiita	Data was not applicable							
Sungura	Data was not available							

Source: second phase licensed science teachers' examination papers terminal examination, 2012)

[17] Biology Form 3 terminal examination
[18] Biology Form 2 terminal examination
[19] Chemistry Form 3 terminal examination
[20] Physics Form 1 terminal examination
[21]No item was testing this cognitive domain level
[22] Biology Form 2 terminal examination
[23] Biology Form 1 terminal examination
[24] Physics Form 1 Physics terminal examination

The stem of the test item consists of wrong words such as 'simple medicine and chemicals', and also the absences of a verb(s), which were likely to confuse students.

Likewise in another question in the Form 3 biology terminal examination, the direction for answering the question was unclear.

Question 7(a) copy and complete the following table

	Gland	One named hormone	Function of named hormone
i	Adrenal		
ii	Ovary		
iii	Pancreas		

Source: Pombe, phase 2 Form 3 terminal examinations 2012.

Constructing test items seems to be challenging for the licensed teachers. For example, Safari also constructed an examination item that was unclear.

> Question 1(iv). The reaction that takes place when limestone ($CaCo_3$) is (A) Combination (B) Double decomposition (C) Replacement (D) Decomposition (E) redox. (Safari, phase 2 form 3 terminal examination 2012)

The stem for this question is incomplete. Other examples of questions that were poorly constructed include:

> Question 9 (b) The aspects of environment is established in two category in regulation. What are those? Define each of them.
> c) Note [sic] down the three types of regulation you know
> 10 (d) Put [sic] down four significance of homoiothermy(s) [sic]. (Qwary, Biology, phase 2 Form 3 terminal examination 2012)

Question 9(b) is unclear because of the poorly constructed stem of the test item, while questions 9(c) and 10(d) are examples of incorrect use of English words and spelling errors.

Constructing tests and examinations seems a challenge for some licensed science teachers, in particular repeating the same test item in other sections testing a similar concept. Some test items that were used in the multiple choice or matching items sections were asked again in other sections, such as short answers-type questions and true-or-false questions. The following examples illustrate this issue of repetition.

> (vii) The following are common accidents at home and schools, except (A) Fire or burns (B) Reading (C) Electric shock (D) Falls. (Pombe, phase 2 Form 2 Biology terminal examination, 2012)

A similar test item was also asked in another section where answers to a previous question (vii) in section ‘A’ are likely to be used by students to answer the question in the subsequent section. The question was:

> Question 3 (c). Mention five common accidents at home and schools how they can be prevented. (Pombe, phase 2 form 2 Biology terminal examination, 2012)

The repetition of the test items was likely to affect the reliability and validity of the assessment. Poor English proficiency was the major factor contributing to unclear test items because licensed science teachers had been translating Kiswahili words directly into English, but these two languages (Kiswahili & English) have different linguistic structures and translating directly is likely to produce grammatical inconsistencies affecting the meaning of the sentence. Also, repetitions of similar test items in other sections are likely to provide students with helpful clues for identifying the correct answer.

5.11 Summary of the chapter and key findings

In summary, the key findings on the impact of the PDI programme implementation on licensed teachers' and students' learning in this study include:

- The licensed science teachers' PCK needs were addressed, their classroom teaching practices had improved and they demonstrated a significant growth in PCK.
- The impact of meeting licensed science teachers' PCK needs was subsequently felt by students, in particular the use of learner-centred teaching methods;
- The licensed science teachers' ability to design and teach lessons using learner-centred teaching methods had significantly improved;
- When classroom observations were pre-planned the licensed science teachers were more effective in teaching the lesson using learner-centred teaching methods, the content of the lesson was well organized and they asked many formative assessment questions during the lesson; and
- Teachers felt that sustainability of school-based PLCs of teachers depends on the availability of support from an experienced facilitator.

In conclusion, licensed science teachers were satisfied with the nature of the professional development implemented and the programme met their PCK needs and expectations. The next Chapter 6 discusses the findings of Chapters 4 and 5.

CHAPTER 6
DISCUSSION AND INTERPRETATION

6.1 Introduction

This study arose from a concern caused by the shortage of qualified teachers in many developing countries in Sub-Saharan Africa. This shortage typically resulted in the recruitment of unqualified/under-qualified teachers using an alternative teacher recruitment approach that by-passed traditional university-based pre-service teacher education programmes (Fyfe, 2007; Geeves & Bredenberg, 2005; Henning, 2000; Humphrey et al., 2008; Kunje & Stuart, 1999; Lynd, 2005; Wedgwood, 2007). Unfortunately, the literature on the quality and effectiveness of these unqualified teachers is inconsistent, being somewhat mixed and divided between opponents and proponents of alternative routes to teacher recruitment and education (Barclay et al., 2007; Legler, 2002; Mitchell & Romero, 2010; Salyer, 2003; Walsh & Jacobs, 2007; Zumwalt, 1996).

Tanzania is a Sub-Saharan African country currently 'trapped' in this method of recruiting unqualified teachers, and the problem is exacerbated by the expansion in secondary education caused by Tanzania's implementation of the MDGs and EFA goals. These untrained teachers who have circumvented conventional pre-service teacher education training are popularly known as licensed science teachers (Ministry of Education and Culture, 2004; Shaban, 2007; Wedgwood, 2007). The literature indicates that such teachers in Tanzania are given some on-the-job training for the purpose of upgrading and certifying teachers which typically involves self-study modules, short residential courses, condensed academic course work and distance learning (Kunje & Stuart, 1999; Owings et al., 2006; Wedgwood, 2007). They receive some professional development support from government agencies. However, there is a paucity of literature on the professional learning needs of licensed science teachers working in schools, in particular those relating to PCK and to strategies for supporting their PCK development other than the use of the distance learning approach and residential self-study.

The purpose of this study was to investigate the current classroom practice of unqualified licensed science teachers recruited in Tanzania by examining their professional learning needs, in particular PCK, and the professional development support they receive for enhancing their PCK. The licensed science teachers took part in professional development training workshops informed by two professional development models: the individually guided model and the teacher network model, as well as best practice reported in the literature on teachers' professional learning and development. This chapter discusses the findings presented in Chapters 4 and 5 in relation to the literature and the research questions. The study was conducted in two phases, the first of which addressed the following four research questions.

i. What are the professional learning needs, especially those relating to PCK, of licensed science teachers in Tanzania?
ii. How effective are Tanzanian licensed science teachers in teaching science using learner-centred instruction?
iii. How do Tanzanian licensed science teachers perceive their current professional development programmes?
iv. What factors could facilitate the sustainable establishment of professional learning communities of licensed science teachers in Tanzania?

The key findings that emerged from research questions (i-iv) included recognising that the licensed Tanzanian teachers in this study had:

- underdeveloped components of PCK, in particular knowledge of instructional strategies, knowledge of science curriculum, knowledge of learners and their characteristics and knowledge of students assessment;
- limited subject content knowledge; and
- limited understanding and use of learner-centred teaching methods in their classroom;

Also it was found that:

- school-based professional development programmes to support licensed science teachers working in community secondary schools do not exist in these schools and the upgrading of licensed science teachers via the distance learning approach was ineffective for teachers working in rural schools; and
- the establishment of PLCs of teachers depends on the availability of well-equipped teachers' resource centres at ward level that are financially supported.

Data from the second phase of the study addressed the following two research questions:

v. How did licensed science teachers in Tanzania perceive the effectiveness of the PDI developed and implemented in this study?

vi. How effective was the implemented PDI in meeting licensed teachers' professional learning needs?

The key findings from this second phase of the research questions included:

- enhancement of the licensed science teachers' PCK and use of more learner focused classroom teaching practices;
- Enrichment of students' learning experiences through the more frequent use of learner-centred teaching methods; and
- The establishment of school-based PLCs of teachers which facilitated the sharing of knowledge and skills by teachers to improve students' learning.

6.2 The licensed science teachers' PCK needs

The discussion in this section is based on the first research question:

i. What are the professional learning needs, especially those relating to PCK, of licensed science teachers in Tanzania?

The licensed science teachers' PCK needs were assessed in order to understand "how teachers take content and transform their understanding of it into instruction that their students can comprehend" (Nuangchalerm, 2012, p. 66), using the PCK framework proposed by Magnusson et al. (1999). The findings of this study have shown that unqualified licensed science teachers' PCK components are underdeveloped, that is, their orientation to science teaching, their knowledge of the curriculum, of how to assess science, of students and their characteristics, and their knowledge of instructional strategies all need to be enhanced. These underdeveloped PCK components of licensed teachers are discussed in the next sections.

6.2.1 The licensed science teachers' orientation to science teaching

A teacher's orientation toward science teaching, which is defined as teachers' knowledge and beliefs about the goals and purpose of science teaching, is a critical component of PCK because it shapes all other PCK components (Friedrichsen & Dana, 2005; Magnusson et al., 1999; Van Driel & Berry, 2010). Magnusson et al. (1999) say that teachers' orientation to science teaching "serves as a conceptual map" (p. 97), influencing their choice of instructional strategies, the content of students' learning activities, how to assess their learning and what textbooks to use (Goodnough & Hung, 2008; Kember & Gow, 1994). The results reported in this study show that licensed science teachers believed that effective science teaching in the classroom depends largely on the availability of teaching and learning materials, in particular laboratory apparatus and consumables, because teachers need to help students conduct experiments to investigate some of the theoretical concepts learned in the science classroom. These teachers' views and beliefs are consistent with the objectives of the science education curriculum in Tanzanian, which stipulates that science teaching should integrate practical and theory for the purpose of developing students' manipulative skills and enabling them to understand scientific procedures and concepts (Ministry of Education and Vocational Training, 2008c). However, it was found that the licensed science teachers were unable to put these beliefs about science teaching into practice as their schools lacked well-furnished science laboratories and had large teacher-student ratios. These contextual factors impacted their choice of teaching strategies, and they opted to use didactic teaching approaches, which were transmissive in nature and emphasized the memorization of scientific facts. Although the lack of teaching and learning materials, such as laboratory apparatus and consumables, and large class size, were the reasons cited for licensed science teachers embracing the transmissive teaching methods, it appears they also lacked the knowledge and skills to improvise even simple teaching aids from the surrounding environment. Findings from previous studies reported that large class size affects student-teacher interactions because it challenges the teacher's ability to assist students as individuals, meaning students feel isolated during teaching (Englehart, 2009).

This thesis indicated that the dominant teaching approach used by the licensed science teachers was didactic, that is, basically a teacher-centred transmissive teaching method that is essentially bookish, leading to students being inactive and passive in the classroom. In fact a teacher's choice to employ a didactic teaching approach may not be how they want to teach, but how they feel they must teach in order to cope with the circumstances. These findings confirm those of P. Brown, Friedrichsen, and Abell (2009), who reported that beginning teachers who were taught using traditional teacher-centred revealed "their science teaching orientations were dominated by the view that teaching is telling and learning is listening" (p. 26). The use of transmissive teaching methods has negative implications for students' learning outcomes, because they are unlikely to learn much beyond the recitation of scientific facts.

This study findings has illustrated that a teacher's knowledge and beliefs about science teaching influences a his or her decision making, in particular the content he or she chose to teach, how to teach, how students' learning could be assessed, especially those with learning difficulties, and how to deal with misconceptions about science, that is, the other PCK components of knowledge of instructional strategies, knowledge of students' assessment, knowledge of the science curriculum and knowledge of students' learning.

6.2.2 Licensed science teachers' knowledge of the science curriculum content

Loucks-Horsley and Matsumoto (1999) argued that teachers' understanding of the content of their teaching subject "is key to learning how to teach subject matter so that students understand it. Teachers cannot help students understand what they themselves do not understand" (p. 262). In other words, effective science teaching requires teachers to be knowledgeable about the science content they are going to teach in schools (Ferguson & Womack, 1993; Segall, 2004). Other literature agrees that teachers with an in-depth understanding of subject content matter are more effective than teachers with limited subject content knowledge (Darling-Hammond et al., 2001; Ferguson & Womack, 1993), and students taught by teachers with a profound knowledge of the content perform better in science and mathematics than those with less knowledge of the subject content (Haycock, 1998). Knowledge of the science curriculum content is the PCK component that includes teachers' knowledge of a curriculum's goals and objectives of teaching science to students and knowledge of specific science subjects (Magnusson et al., 1999), which teachers first begin to acquire during their academic studies and pre-service teacher education that is later enriched through teaching experience (Van Driel & Berry, 2010).

This thesis found that licensed science teachers lacked an understanding of subject content. They acknowledged depending on having knowledge of the subject content they had obtained from junior and high school training since they had not attended university nor had they been provided with any pre-service teacher education or teaching internship. As a result of inadequate subject content knowledge in some science topics they avoided teaching, especially those they had not covered in their own high schooling. This skipping of topics resulted in a mismatch between the implementation of the 'formal' (intended) science curriculum and the 'operational' (implemented) science curriculum. The licensed science teachers felt that their knowledge and skills in teaching specific subjects such as chemistry, physics and biology, and more importantly how to teach science practicals, need to be polished in order to improve their classroom teaching. Their inability to prepare science practicals suggests that science teaching in Tanzanian community secondary schools is unlikely to involve students in hands-on activities, such as doing experiments, testing theories, verifying laws and proving hypotheses.

The finding that Tanzanian licensed science teachers felt they have inadequate knowledge of science content is not surprising, given that their educational qualifications reflected lower passes in the high school examinations. Because the licensing of these science teachers by-passed the traditional university-based pre-service teacher education, which is an important source for new teachers to acquire initial PCK (De Jong & Van Driel, 2004; Howey & Grossman, 1989; Nezvalová, 2011). This gap in their professional development suggests they are even weaker in terms of both content and pedagogical knowledge than novice teachers who have received pre-service teacher education. If this is true, then it is worrying that, as Käpylä, Heikkinen, and Asunta (2009) observed, the subject content knowledge of trained biology novice teachers “has been characterised [as] piecemeal, less structured, and having more mistakes or inaccuracies” (p. 1397). This thesis has found that the limited subject content knowledge of the licensed teachers impacted their ability to make a connection between scientific ideas and students’ daily environment, as they depended mostly on examples written in students’ textbooks. They taught science without addressing misconceptions about science or students’ naïve scientific ideas. These teachers were seen to rely on subject textbooks and their old teaching notes, which they used for teaching - sometimes dictating scientific concepts directly from these sources with students repeating the dictated words.

These findings are consistent with those reported by Käpylä et al. (2009) and Hashweh (1987), who observed that novice teachers with inadequate subject content knowledge lack the skills to correct misconceptions about science, and have difficulty developing a connection between scientific ideas in their classroom teaching. Moreover, novice teachers usually transfer their own misconceptions to their students during classroom instruction (Hashweh, 1987). Using teachers with inadequate knowledge of subject content is likely then to have negative implications for students’ learning because the lack of subject content knowledge impacts on novice teachers’ ability to plan effective lessons, provide relevant examples and choose appropriate instructional methods. These findings are in line with work by Käpylä et al. (2009), who said that novice teachers' "lack of sufficient content knowledge influenced their planning of the lesson and probably would also make the real teaching difficult" (p. 1405). Gess-Newsome (2002) also observed that teachers with inadequate subject content knowledge depend heavily on textbooks and officially approved curriculum materials for teaching. In contrast, teachers who have strong subject content knowledge "give details in their lesson, link the topic to other topics, ask students many questions, and stray from the textbook" (Adedoyin, 2011, p. 278); and are more effective in developing students' learning tasks that "require higher-order thinking and problem solving" (Darling-Hammond, 2000a, p. 167). The findings from this study suggest that licensed teachers' inadequate subject content has negative implications for students' learning outcomes, because classroom teaching was reduced to mere memorization that did not promote science students' higher-order learning and thinking.

6.2.3 Licensed science teachers' knowledge of learners and their characteristics

Knowledge of learners and their characteristics PCK component in science, according to Magnusson et al. (1999), refers to "the knowledge teachers must have about students in order to help them develop specific scientific knowledge. It includes two categories of knowledge: requirements for learning specific science concepts, and areas of science that students find difficult" (p. 104). This PCK component also includes teachers having an understanding of students: their motivation for learning; the diversity in their learning ability and learning style, their interest in the subject and their needs; and their cognitive developmental level (Park & Oliver, 2008). In this thesis the findings from the first phase revealed that the teachers did not have strong knowledge of their learners and their characteristics. Interestingly only two (Manimo and Tiita) out of six teachers felt that it is essential for teachers to be knowledgeable about their students' learning needs, such as how to teach students with special needs or how to use different psychological principles to enhance their learning. It appears that the other licensed science teachers lacked a strong understanding of the importance that knowledge of learners and their characteristics had for teaching. The licensed science teachers’ lack of strong views about knowing their students and their characteristics could possibly be attributed to the recruitment approach that precluded them from attending pre-service teacher education, which is believed to be a preliminary source of PCK. This finding might also suggest that these licensed science teachers were teaching students without taking into consideration students’ motivation during teaching, what learning difficulties they were experiencing in the subject, and how these learning difficulties are to be addressed. Käpylä et al. (2009) observed that novice biology teachers were unaware of students' learning difficulties, while experienced teachers were partially aware. Teachers with an underdeveloped knowledge of learners and their characteristics usually place the onus on their students when they face difficulties understanding the content being taught instead of on their failure as teachers to facilitate students’ learning appropriately (Käpylä et al., 2009).

However, during the second phase of this study where the teachers were involved in professional development, the PCK component of knowledge of learners and their characteristics strongly featured in licensed teachers’ views and classroom practices, and they practised learner-centred pedagogy as their teaching became more aligned to individual students’ learning needs. This finding is similar to P. Brown et al. (2009), who reported that alternative route teachers, who had participated in an internship programme under the guidance of mentors, changed their understanding of students’ difficulties and were able to accommodate their learning needs. Other previous studies support the view that teachers who are knowledgeable about learners and their characteristics help students to address their misconceptions about science and overcome learning difficulties like the learning of abstract science concepts (Magnusson et al., 1999; Park & Oliver, 2008). However, Magnusson et al. (1999) cautioned that some teachers, despite having some knowledge of students have difficulty teaching students to overcome their misconceptions and learning difficulties, because the teacher’s experience matters most when addressing students’ learning difficulties.

6.2.4 Licensed science teachers' knowledge about planning instructional artifacts

Findings from previous studies have suggested that lesson planning is central to effective classroom teaching and students' learning because a pre-planned lesson improves student-student interaction and teacher-student interaction, provides teachers with the opportunity to reflect and teach according to students' learning needs, and helps as a guide for evaluating student learning (Boikhutso, 2010; Houston & Beech, 2002; Jones, 1998). Craft and Bland (2004) stated that lesson planning "allows teachers to deliberately step through each piece of the instructional process, from determining formative assessments and criteria to selecting specific teaching methods and student activities, to judge if each one is a good match for the outcome and components" (p. 91). This thesis finding indicated that licensed science teachers appeared confused by the different terminologies used in the lesson plan templates and schemes of work provided by the MoEVT, such as *student assessment*, *teacher evaluation*, *student evaluation*, *reflection* and *lesson reinforcement*. They appeared not to know what to put in some of these sections and were not even sure who was supposed to fill them in. Their inadequate understanding of lesson planning suggests that the PCK component of knowledge of instructional strategies is significantly underdeveloped, and needs to be enhanced. Their lesson plans also contained many flaws, for example, lesson objectives were not consistent with students' assessment activities, and some teachers were unable to differentiate *specific lesson objectives* - a "statement that describes exactly what a student will be able to do in some measurable way" (Hartel & Foegeding, 2004, p. 69) from *lesson competencies* - a "general statement detailing the desired knowledge and skills of student graduating from our course or program" (Hartel & Foegeding, 2004, p. 69). This confusion and inconsistency in their lesson planning artifacts suggests that the induction course that was conducted to meet licensed science teachers' initial professional learning needs was ineffective. This finding illustrates the potential effect of recruiting teachers without giving them proper pre-service education. Previous studies have reported that teachers recruited through the alternative route "tend to have greater difficulties planning [the] curriculum, teaching, managing the classroom, and diagnosing students' learning needs" (Darling-Hammond, 2000c, p. 8), consistent with the present work. The licensed science teachers' underdeveloped knowledge of instructional strategies in the study certainly seems to have had an impact on lesson preparation, as their teaching was unorganized, lessons were not interactive, and students seldom engaged in higher-order thinking in their classes.

According to Panasuk and Todd (2005), mathematics teachers from urban low-performing middle schools engage in effective lesson planning when they integrate subject content knowledge and knowledge of instructional strategies. Therefore, given the licensed teachers' weak subject content knowledge and poor knowledge of instructional strategies, it implies that their ability to prepare effective lessons is further inhibited. To add to their difficulties, the study reported that the amount of time licensed science teachers had for preparing their lessons was inadequate since they were overloaded with a high number of teaching hours and other school responsibilities. Combined with the lack of resources and large number of students, the teachers were in effect forced to teach their lessons without preparing lesson plans and schemes of work. However, previous studies have indicated that trained novice teachers with fewer demands than these licensed teachers characteristically avoid doing lesson preparation and they teach students without pre-planning their lesson (John, 2006; Thomas et al., 2008), because lesson planning is perceived to be a tedious and time-consuming activity (Jones, 1998). So the findings in this study are not that surprising. In another study conducted in Tanzania, Thomas et al. (2008) reported that "often teachers come to class with only their lecture notes, making the lesson unengaging for students, especially those who are not fluent in English" (p. 17).

The licensed science teachers' lack of understanding on how and what to put in the sections of a lesson plan and schemes of work templates points to a possible lack of knowledge sharing between professionally trained and/or experienced teachers and novices like licensed science teachers recruited via the alternative approach. This implies that school-based professional development support does not provide these opportunities in the case study schools. However, Kardos and Johnson (2007) reported that two-thirds of new or novice teachers plan and teach alone and receive no professional learning support from experienced teachers to improve their knowledge and teaching skills. For instance, learning via unplanned teaching means that students were being imparted with lower-level cognitive skills and would not acquire problem-solving skills because classroom teaching pedagogy was dominated by teacher-centred teaching methods intent on the transmission of facts and their recitation by learners. The outcome of imparting students with lower level cognitive skills and problem-solving skills results in an education system that produces low achievers and citizens who cannot contribute to the prosperity of the nation.

Past research studies consistently agree that when teachers share their teaching experiences and work collaboratively as a PLC of teachers supported by the school leadership they expand their PCK and consequently improve student learning outcomes (Kwakman, 2003; Lieberman, 1995; Vescio et al., 2008). As Lieberman (1995) explains, “networks, collaboration and partnerships provide teachers with professional learning communities that support changed teaching practices in their own schools and classrooms” (p. 75). Levine and Marcus (2010) added that:

> In a community of practice, novices—and experienced practitioners—can learn from observing, asking questions, and actually participating alongside others with more or different experience. Learning is facilitated when novices and experienced practitioners organize their work in ways that allow all participants the opportunity to see, discuss, and engage in shared practices. (p. 390)

These views imply that the PCK needs of Tanzanian licensed science teachers who missed out on the pre-service education and a teaching internship can be met through a school-based community of practice if the school leadership creates and supports a learning environment conducive to the sharing of skills and knowledge between novice and experienced teachers. In such a learning community the likelihood is that licensed teachers PCK components may be enriched and heightened.

6.2.5 Knowledge of assessing and evaluating students' learning

Assessment and evaluation are an essential part of classroom teaching because both assessment and evaluation provide information from students that teachers use to improve classroom instruction and student learning (Baeh, 2005; Frey, Petersen, Edwards, Pedrotti, & Peyton, 2005; Shepard, 2000). According to Baeh (2005) assessment "provides feedback on knowledge, skills, attitudes, and work products for the purpose of elevating future performances" while evaluation "determines the level of quality of a performance or outcome and enables decision-making and learning outcomes" (p. 7). The literature also reports that teachers with a strong knowledge of assessment skills contribute significantly to students' effective learning,, while teachers with weak knowledge of students' assessment can harm their learning (Stiggins, 1992). This thesis finding has indicated that licensed science teachers were confused about the use of the terms assessment and evaluation as used in their lesson schemes of work and lesson plan templates because they believed these two terms were similar. This finding confirms previous work by Baeh (2005), who observed that evaluation and assessment are distinctly different but use similar strategies and processes and this causes confusion to teachers. He argued that assessment looks at how to improve students' performance or outcome in the future, while evaluation looks at the quality of performance at a particular level. Baeh (2005) cautioned that "there can be detrimental effects when the people [teachers] involved have not agreed whether the process is evaluation or assessment, or when the assessment methodology gets confused with the evaluation methodology" (p. 7). Therefore, the licensed science teachers' confusion about assessment and evaluation appears to have negative implications for students' learning, in particular, evaluation of student learning outcomes.

An investigation into the tests and examination items prepared by the Tanzanian licensed science teachers indicated that they lacked the ability to develop test and examination items that evaluate students' higher-order cognitive skills. The finding exposed two major pedagogical weaknesses in the tests and examinations prepared by licensed science teachers. First, the tests and examinations predominantly assessed the lower levels skills of Bloom's knowledge categories, and, secondly, some test and examination items were grammatically inconsistent and unclear, meaning that they could not be understood by the students. Bloom (1956) proposed six levels of cognitive knowledge (knowledge, comprehension, application, analysis, synthesis, and evaluation) that need to be assessed when teachers evaluate students' learning. Bloom's cognitive knowledge categories are widely accepted and frequently used in education as a guide for constructing test and examination items to evaluate students' learning (Crooks, 1988; Eber & Parker, 2007; Marso & Pigge, 1991; Omar et al., 2012).

The tests and examinations devised by the licensed science teachers were skewed toward the lower-level cognitive categories of knowledge, comprehension and application, with few questions testing the higher cognitive knowledge categories of analysis, synthesis and evaluation (Bloom, 1956). This finding suggests that the assessment component of licensed science teachers' PCK is underdeveloped and needs to be enhanced. It appears that the licensed science teachers avoid or are unable to test Bloom's higher-order cognitive knowledge categories, such as analysis, synthesis, and evaluation. This study found that the use of a *table of specifications* or *test blueprint* appeared to be new to licensed science teachers since in the past they constructed their test and examination items without using one. A table of specifications is considered crucial in test construction because it promotes test content validity, and it provides teachers with the scope and areas of subject content that need to be tested (Notar, Zuelke, Wilson, & Yunker, 2004). This thesis finding suggests that licensed science teachers' inadequate knowledge of using a table of specifications as a guide for constructing test items contributed to test and examination questions that tested lower-level cognitive skills. It could also reflect the fact that they impart lower level-cognitive skills, which in turn affects students' ability to acquire higher-order cognitive skills, such as problem solving and critical thinking. Studies have shown that the practice of teachers evaluating complex skills by asking higher-level cognitive questions helps students to develop critical thinking skills (Eber & Parker, 2007; Limbach & Waugh, 2010). There is strong evidence in the literature that the "use of higher-level questions in evaluation enhances learning, retention, transfer, interest, and development of learning skills" (Crooks, 1988, p. 442). The licensed science teachers' inability to construct higher-order cognitive questions suggests that the induction programme did not equip the trainees with the knowledge needed to evaluate students' learning.

Despite this study's finding that a lack of pre-service education is a key reason for licensed science teachers' inability to construct test items that evaluate higher-order cognitive skills, previous studies report that even teachers with credited pre-service education have difficulties putting Bloom's knowledge categories into practice in their teaching and assessment (Crooks, 1988; T. Thompson, 2008). The findings of this study concur with numerous international studies that most teacher-made tests were found to predominantly test the 'knowledge' level that involves students in reciting and recalling facts (Crooks, 1988; Kudzai, Moses, & Emily, 2011; Marso & Pigge, 1991). For example, Crooks (1988) reviewed international literature on teacher-made tests by French teachers from elementary to high school and found the "extensive use of questions at Bloom's lowest (knowledge) level … almost 80% of all questions were at the knowledge level" (p. 442). Similarly, (p. 442); Marso and Pigge (1991) in their analysis of teacher-made test in the US found that "72% of the 6529 items were functioning at the knowledge level, 11% at the comprehension level, 15% at the application level, 1% at the analysis level, and fewer than 1% of the items at the synthesis and evaluation levels" (p. 281). Past studies reported that teachers usually opt to ask lower-level cognitive questions for the following reasons. First, they are easy to grade and they lack the skills and knowledge for writing higher-order test items; second, teachers believe that higher-order cognitive questions usually confuse students, cause them anxiety, thereby resulting in failure; and third, higher-order cognitive skills questions are difficult to grade (Crooks, 1988; Gall, 1970; Kudzai et al., 2011; McMorris & Boothroyd, 1993). For example, Kudzai et al. (2011) observed that teacher-made tests are skewed toward lower-level cognitive skills because teachers' "ignorance of Bloom's taxonomy in test construction also produced tests for the sake of producing tests" (p. 443). It appears from the perspective of these previous studies that many teachers do not understand and follow the principles of test construction to construct high quality test and examination questions. The inability to construct test items that evaluate both lower-level and complex skills in a balanced way is an enduring problem facing most teachers, whether or not they have received pre-service education.

This thesis' findings has indicated that test and examination questions prepared by licensed science teachers consist of many errors and some questions were not constructed according to the principles of test construction reported in measurement and evaluation literature (see Gronlund, 1985; Gronlund & Linn, 1990; Popham, 2013; Rani, 2004). Findings from previous studies reported that common errors in some teacher-made tests include: the violation of test construction rules, directions or procedures for answering questions are unclear or not given at all, some items are not numbered, unnecessary trick questions, ambiguous test items, test items which are either too difficult or too simple, and poorly written items that are too confusing to attempt (Frey et al., 2005; Kudzai et al., 2011; Marso & Pigge, 1991). These test construction ambiguities are likely to confuse students during examinations and also jeopardize the validity and reliability of the examination (Kudzai et al., 2011). Frey et al. (2005) outlined two reasons for test construction errors in most teacher-made tests: first, teachers were inadequately prepared by their pre-service teacher education to construct high-quality test and examination items; second, the absence of clear or consistent guidelines on test construction or written test items that were made available to help teachers to continually learn about test construction in their respective schools after pre-service teacher education.

6.3 Licensed science teachers' effectiveness in the use of learner-centred teaching methods

The discussion in this section is based on the second research question

ii. How effective are Tanzanian licensed science teachers in teaching science using learner-centred instruction?

Classroom observations and interviews revealed that the Tanzanian licensed science teachers did not understand or use learner-centred teaching methods in their pedagogy. Their classroom practice was dominated by teacher-directed learning while the students' role in the classroom was to copy notes the teacher had written on the blackboard. The most likely reason for this classroom practice is that licensed teachers relied on the limited methods used to teach them when they were students in junior and high school. Also, learner-centred teaching methods are new to Tanzanian teachers and are still not properly understood and used in schools so there were few models for the licensed teachers to follow (Kitta & Tilya, 2010). These findings suggest that given the lack of pre-service teacher education and background experience in the use of learner-centred teaching methods, licensed teachers mimic the teaching styles of their 'master teacher'—a term used by Stamatel (2003) to identify the previous teachers of novice or untrained teachers, whose classroom practices they imitate because they considered them a master teacher. It is common for novice teachers to imitate teaching methods "without completely understanding the principles behind such teaching" (Young, Bullough, Draper, Smith, & Erickson, 2005, p. 186). Teaching students using learner-centred methods requires teachers with a strong content knowledge (Sikoyo, 2010), who do extensive pre-planning of their lesson before the actual business of teaching in order to effectively facilitate student learning (O'Neill & McMahon, 2005; Wohlfarth et al., 2008). However, because Tanzanian licensed science teachers lack a comprehensive understanding of subject content, they tend not to plan their lessons regularly and so they teach without a prior action plan. The licensed science teachers' lack of pre-planning and lack of knowledge of the subject content meant that students' classroom activities or lessons were often unclear, and the teachers did not provide interactive activities for their students in their teaching. From the licensed science teachers' perspective, learner-centred instruction simply meant arranging students in groups to discuss the lesson. This finding concurs with the finding by Altinyelken (2010) that qualified primary school teachers in Uganda also interpreted learner-centred instruction "as more student talk and activity within the classroom" (p. 161). However, Ugandan teachers are reported to use teaching aids to facilitate students' learning in their classrooms and they have a positive perception of the value of learner-centred teaching methods, while this present thesis' findings indicated that most Tanzanian teachers teach without any teaching aids.

It appears that their inadequate understanding of learner-centred pedagogy has limited licensed science teachers' classroom practice to mere transmission of information to students and they have been unable to create an interactive learning environment for students to contribute during the teaching and learning process. They ask questions using a 'rapid-fire' approach without waiting for students to think about the answer, and frequently provide the answer themselves to the questions they had asked their students. Their teaching is characterised by a whole classroom instruction approach that requires students to provide chorus answers as if they were addressing a public forum. The licensed teachers' classroom practice prevented students from being partners in the learning and teaching process as recommended in the learner-centred education literature (Sikoyo, 2010; Weimer, 2002). This finding contradicts the tenets of learner-centred teaching (Weimer, 2002), where during instruction the teacher-student power relationship is symmetrical in nature, and the teaching emphasis is on understanding the content and sharing knowledge, and learning is evaluated on the basis of individual student outcomes. The teacher's role in learner-centred classroom teaching is to facilitate students' construction of knowledge. During learner-centred teaching, teachers are ideally guided by the values of the constructivism learning theory—that learning is an active process involving collaborative engagement, through the construction of knowledge instead of passively accepting knowledge from teachers, with the key focus of teaching being on individual student learning (Chiang et al., 2010; Mayer, 2004).

Despite the Tanzanian science education curriculum putting more emphasis on teachers using learner-centred teaching methods, the licensed science teachers are using conventional teacher-centred approaches in their classrooms. This means that there is a mismatch between the official/formal science curriculum and its implementation in the classrooms of licensed teachers in Tanzanian community secondary schools. Their classroom practice in this study indicated that a paradigm shift from teacher-centred to learner-centred teaching approaches is yet to be achieved by these teachers. As Ho, Watkins, and Kelly (2001) reported, these licensed teachers like:

> ... teachers at all levels hold personal conceptions of teaching which are developed from their long years of classroom experience as students and subsequently as teachers … teachers' prior conceptions of teaching [need to be changed] to one of facilitating student learning … before specific student-centred strategies could be eventually adopted. (pp. 144-145)

To transform their conception of teaching from that of conventional teacher-centred approaches to that of learner-centred teaching approaches, Tanzanian licensed science teachers need professional learning support.

This study's finding revealed a mismatch between licensed science teachers' actual practice and their views expressed during the interviews. Before the intervention they talked about using formative assessment to evaluate their classroom teaching, but classroom observation rarely recorded them using formative assessment techniques. For example, they seldom checked on whether or not students had understood the lesson, implying that these teachers do not understand the significance of monitoring students' learning. They did not know how to conduct formative assessment, which relates to their underdeveloped PCK, that is knowledge of topic specific instructional strategies, the science curriculum, students' assessment and knowledge of learners. Altinyelken (2010) when reporting on teachers' use of learner-centred pedagogy in Ugandan primary schools also noted that in interviews with teachers they claimed that they use learner-centred pedagogy regularly in the classroom, while observation of their classes found that they only partially use the new learner-centred pedagogy.

Interestingly, licensed science teachers also claimed that students are not interested and rarely contribute to the lesson when classroom teaching is learner-centred, particularly in Forms 1 and 2 (13-14 years students). They believed that students in lower classes actually prefer teacher–centred pedagogy, although classroom observation found that teachers' classroom practice in Forms 3 and 4 (15-16 years) was no different from that of Forms 1 and 2 (13-14 years students). However, the views of students in their focus group discussion were found to contradict the licensed science teachers' belief that students are less interested when instruction is learner-centred. Regardless of their schooling level, students showed interest in learning using learner-centred instruction, and regarded it as an effective instructional method. They felt that they learnt more effectively when classroom teaching is more learner-centred. This finding implies that the licensed science teachers' beliefs about students not wanting to participate during learner-centred instruction might have also contributed to their classroom practice embracing teacher-centred pedagogy. It illustrates that licensed science teachers' beliefs about learner-centred learning needs to be challenged, ideally through professional development training. There is also a need to encourage the use of learner-centred teaching methods in Tanzanian primary schools to expose students to the value of learner-centred teaching methods. This finding is in line with the work of Hunde and Tegegne (2010), who worked with Ethiopian secondary schools teachers and students. They reported that students positively support the use of learner-centred instruction but "teachers complained that they couldn't implement student-centred instruction mentioning problems from students' side such as shyness, language barriers, lack of confidence, and lack of awareness about the value of student-centred approach which are directly or indirectly linked with interest" (Hunde & Tegegne, 2010, p. 53). Some of these perceived barriers relating to the Tanzanian context are discussed in the next subsection.

6.3.1 Perceived barriers preventing teachers from using learner-centred teaching methods

Although in the context of this study the lack of pre-service teacher training is assumed to be the main reason for licensed science teachers' inadequate understanding and use of learner-centred methods, there are also other contextual factors that caused these teachers to feel unable to teach students using learner-centred teaching methods in Tanzanian community secondary schools. The licensed science teachers believed that factors such as using English as the medium of instruction, large class sizes, teaching load and inadequate teaching and learning materials did not encourage them to use learner-centred teaching methods in Tanzanian community secondary schools.

6.3.1.1 English as the medium of instruction as perceived barrier to effective classroom teaching

According to Rollnick (1998) language "is a central factor to all learning. Its importance in the learning of science has often been underestimated … language cannot be ignored as it impinges on the learning of science in important ways related to both attitude and cognition" (p. 121). There is agreement in the literature that students with limited English face difficulties learning the academic content of their subject using this unfamiliar language (Brock-Utne & Holmarsdottir, 2004; Lara-Alecio et al., 2012; Rollnick & Rutherford, 1996; Senkoro, 2005). It is through language that teachers and students communicate their thoughts in the classroom and the use of a familiar language of instruction effectively facilitates the discourse of classroom teaching (Brock-Utne & Holmarsdottir, 2004; Rollnick, 2000). The findings of this study have shown that both teachers and students were limited in their use of English during the lessons, particularly when expressing scientific concepts during the teaching and learning process. As a result, students appeared shy when expressing their views in English and teachers frequently engaged in code switching (i.e., switching languages between sentences) and code mixing (i.e., switching languages within the same sentence) from Kiswahili to English and vice versa

(Brock-Utne & Holmarsdottir, 2004; Leyendecker, Ottevanger, & van den Akker, 2008; Rollnick & Rutherford, 1996). This practice suggests that both teachers and students have limited English vocabulary, which has probably impacted the teachers' ability to teach students using learner-centred instructional strategies, because it requires both students and teachers to have a high level of proficiency of the medium of instruction. According to Vavrus et al. (2011) teachers' and students' proficiency in the medium of instruction is crucial to effective learner-centred classroom instruction. Vavrus et al. (2011) argued that learner-centred teaching:

> … relies heavily on critical thinking and dialogue, students and teachers need not only adequate space for discussions but also the linguistic skills in the MOI [medium of instruction] to express complex ideas and to ask critical questions. Thus, LCP [learner-centred pedagogy] places significantly higher linguistic demands on teachers and students than teacher-centred approaches (p. 81).

This thesis is of the view that the licensed science teachers' lack of proficiency in English and limited content knowledge are the most likely reasons for poor classroom interaction between students and teachers – as teachers were unable to facilitate classroom discussion, relying instead on dictating scientific concepts from the textbook, which students copied. This classroom practice means that licensed science teachers' limited English ability hinders them from providing scientific examples that engage students in problem solving and impart higher-order cognitive skills. The lack of competence in speaking English also impacted students' ability to convey their scientific ideas freely and with confidence. Other researchers confirm that using a language of instruction that is not familiar to students or teachers and is not their first language is a barrier to the implementation of learner-centred curriculum reforms (Hunde & Tegegne, 2010; Leyendecker et al., 2008; Vavrus et al., 2011). Lack of fluency in the language of instruction tends to increase teachers' frustration during instruction, causes confusion on the part of the students, results in poor student learning and disciplinary problems in the classroom, and encourages greater use of teacher-centred instruction (Howie, 2002). Some studies reported that when classroom teaching is conducted using students' mother tongue or a language in which they are conversant and used by them in their home environment, students understand instruction better, and their examination achievement in science, mathematics, and English is higher than those students with limited understanding of language of instruction (Brock-Utne, 2007, 2012a; Howie, 2002; Rollnick & Rutherford, 1996; Vuzo, 2010; Yip, Tsang, & Cheung, 2003).

Despite the official statements in education and training policy documents that English is the medium instruction in Tanzanian secondary schools (Ministry of Education and Culture, 1995), the licensed science teachers' limited ability to converse in English has forced them to adopt code switching or code mixing from English to Kiswahili as a survival strategy during teaching and learning in the classroom. They also do this to make the lesson more understandable to learners. Their limited English proficiency was also reflected in test and examination questions, with the result that their papers were marred by numerous English grammatical errors. These flaws in the tests are likely to confuse students. The observed inability to converse in English by both teachers and students in Tanzania can be attributed to many factors. First is the lack of a foundation in English at family and primary levels because of the multilingual nature of Tanzanian society whereby children first learn the local (vernacular) language at family level (from 1-6 years), and then Kiswahili as the medium of instruction in primary school (from 7-13 years). In primary schools English is studied as a subject, followed by a complete change from Kiswahili to English at secondary school as the medium of instruction (from 14+ years). Secondly, English is taught as a language at primary school by teachers whose English is also limited and some are not qualified English teachers (Barrett, 2007; Senkoro, 2005). Thirdly, there are inadequate English language teaching materials available in schools (Brock-Utne, 2007, 2012b; Vuzo, 2010). The issue of the medium of instruction has recently caused a heated debate amongst Tanzanian education stakeholders and citizens at large. The opponents of English contend that its use as the medium of instruction has produced uninspiring results, and so there is a need to change to Kiswahili as the medium of instruction (Brock-Utne, 2012b; Legère, 2010; Vuzo, 2010). In contrast, the proponents of English argued that Kiswahili is still in its infancy and not developed enough to be used as the medium of instruction, and that students with Kiswahili will not be able to compete in the world economy dominated by English (Kilemile, 2012; Omari, 2007). This debate has not yet been resolved and it is not clear if Tanzania should use English or Kiswahili from primary to university level. This English-Kiswahili debate has recently taken a new direction as Kiswahili activists have put forward a recommendation that Tanzania's new constitution formally recognize Kiswahili as the official medium of instruction from primary to university level. The language of instruction debate is a controversial issue and has political elements (Rollnick, 1998). For example, this move by the activists started in the early 1980s (Brock-Utne, 2012b), but they have not yet persuaded the Government to change its stance on the language of instruction policy.

6.3.1.2 Inadequate teaching and learning materials, large class size, and teaching load

As regards the shortage of teaching and learning materials, the classrooms in the case study schools lacked basic materials and resources such as chairs, textbooks, a library, science laboratories and laboratory consumables. The lack of students' textbooks in particular has created a dependency culture among students in the classroom, whereby teachers copy notes on to the blackboard and students passively transfer them into their books. Licensed science teachers were often found using their old secondary schools exercise books or notebooks as a source for teaching students. Another challenge to implementation of learner-centred instruction in the researched schools was the large size of the classes. Most classrooms were overcrowded (an average of 70 students per class), which was a huge barrier for licensed science teachers with underdeveloped PCK to effectively teach their lesson.

Also, the absence of science laboratories, chemicals and other laboratory consumables in some of Tanzanian community secondary schools meant that the teaching of science (physics, biology and chemistry) was no different from teaching the social sciences (English, history geography), which need less hands-on activities than the sciences. Science practicals were done by students memorizing the diagrams of different science laboratory apparatus and sketches showing how to assemble the apparatus. This mode of learning meant that students also had to memorize the results of the experiment as if they had conducted and observed the results of real scientific experiments for themselves. The shortage of teaching and learning materials, large classes and teachers with many hours of teaching is not uncommon in African countries' classrooms, and is consistently reported by other researchers (Altinyelken, 2010; Brodie et al., 2002; Nykiel-Herbert, 2004; Sikoyo, 2010; P. Thompson, 2013; Vavrus, 2009; Vavrus et al., 2011).

In summary, this finding confirms previous work by Brodie et al. (2002) that teachers' take-up of learner-centred pedagogy depends on them having "access to resources and support structures in their schools" (p. 556). The shortage of resources and the lack of a support structure in schools clearly compromised the implementation of learner-centred pedagogy. Tanzanian licensed science teachers' underdeveloped PCK limited them from designing and teaching science lessons effectively using learner-centred teaching methods, because the implementation of learner-centred instruction depends on teachers' competency in subject knowledge, pedagogy and understanding students (Brodie et al., 2002; Nykiel-Herbert, 2004), which is the missing ingredient in Tanzanian licensed science teachers. In fact, learner-centred instruction is non-existent in the classes taught by the licensed science teachers observed during this study.

6.4 School-based professional development support for licensed science teachers

The discussion in this section is based on the third research question

iii. How do Tanzanian licensed science teachers perceive their current professional development programmes?

The Tanzanian Government, through the MoEVT, promised during the recruitment of licensed science teachers that these novice teachers would receive school-based mentoring or peer coaching from experienced teachers in their respective schools (Ministry of Education and Culture, 2004). However, the findings of this study have shown that such school-based professional development does not in effect exist in the case study secondary schools. The licensed science teachers were given lesson artefacts (such as lesson plan templates, scheme of work templates and syllabuses) before being introduced to the students and shown which classes to teach; however, none were given a mentor to provide induction into the actual classroom environment. A possible explanation for this finding is that the Tanzanian community secondary schools in this study were mostly staffed by inexperienced or untrained teachers, particularly those teaching science and mathematics, and the few that were available were overloaded by many hours of teaching. This situation means that there were no experienced teachers in a position to provide the support needed to mentor novice teachers. The thesis findings also suggest that mentoring is not yet established in Tanzanian community secondary schools, so school-based professional development support appears unrealistic in the current context of Tanzanian community secondary schools. This study has revealed that inexperienced and untrained licensed science teachers were given the full responsibility for teaching and overseeing students' academic and social growth, when in fact the Government asserted that the licensed science teacher "must have the supervision of senior teachers or the headmaster" (Semali & Mehta, 2012, p. 231) to support them at the initial stage of immersing them in the teaching profession. It would seem that the headmasters or senior teachers were unaware of the responsibilities allotted to them.

The rare professional development opportunities that were potentially available to licensed science teachers were not offered because the school administration regarded them as temporary teachers who might leave teaching without providing notice. This situation is similar to that reported in the United Arab Emirates where Ibrahim (2012b, pp. 539-540) observed that "beginning teachers are not provided the support they need and, thus, suffer a 'reality shock' as they come to realise that they are not prepared to meet the challenges they face when they first begin teaching in their own classrooms". All novice teachers in the beginning of their teaching career face challenging situations such as new curriculum, teaching context, culture and school politics, insufficient understanding of their learners and how they learn science (Davis, Petish, & Smithey, 2006; Stanulis, Little, & Wibbens, 2012). Regardless of the quality of the pre-service education they have undergone, novice teachers anywhere are often in ‘survival mode’ initially and they need school-based guidance to overcome these challenges (Bartell, 2004; Davis et al., 2006; Ibrahim, 2012a, 2012b). Feiman-Nemser (2001) argued that no matter how good pre-service teacher education is, most aspects of teaching are learnt on the job. Thus, school-based professional development support, such as mentoring and peer coaching, is especially crucial for helping licensed science teachers to overcome the challenges of teaching in their initial stages of their teaching career. Previous studies have reiterated that school-based mentoring plays a critical role in supporting new teachers to acquire teaching competencies (Hobson et al., 2009; Lambson, 2010), and that good mentoring improves the retention of new teachers in the profession (Piggot-Irvine, Aitken, Ritchie, Ferguson, & McGrath, 2009).

Apart from school-based professional development the Tanzanian Government also declared that, upon deployment, licensed science teachers “will be trained for certification through distance education programmes, to be offered by OUT or through other regular college/university based programmes” (Carr-Hill & Ndalichako, 2005, p. 73). However, despite the Government’s provision of distance learning to train and upgrade the licensed science teachers’ qualifications and help them acquire professional teaching skills while working, this study suggests that the distance learning programme of the OUT was ineffective and impractical for licensed science teachers in the context of Tanzanian community secondary schools. Obstacles such as lack of financial support, teaching and learning materials, internet facilities, and overloaded teaching schedules made it difficult for licensed science teachers to study via the open distance learning approach, which in turn caused a high attrition rate of licensed science teachers enrolled at the OUT. This study’s findings are similar to previous study conducted by Sikwibele and Mungoo (2009) in Botswana when it was reported that the:

> … problem associated with distance learning is high attrition rates … situational barriers included a poor learning environment and a lack of time; for example, students felt that the course took more time than anticipated because they had to juggle the demands of work, home, and school. (p. 4)

Also, the distance education programme in Tanzania had a number of organizational weaknesses – for example learning materials were not delivered on time or got lost in transit, and the time for tests and examinations was not known by student teachers. Additionally, the findings show that the distance education programme worked on the assumption that 'one size fits all'—that all teachers, regardless of the working location such as rural or urban, were treated equally as if they have similar opportunities in terms of access to learning resources. These challenges negatively impacted some of the licensed science teachers in terms of completing their studies, particularly those in rural areas, some of whom had enrolled more than three years before, but were still doing some first-year education courses at time of the study.

Interestingly, this work also indicated that the classroom teaching practices of the licensed science teachers already enrolled and studying at the OUT and those not enrolled were not significantly different in terms of their ability to teach their subjects using learner-centred instruction. This suggests that the distance learning programme was not particularly effective in meeting licensed science teachers' professional learning needs, particularly their ability to teach using learner-centred instruction. Sikwibele and Mungoo (2009, p. 4) observed that "dependence on traditional methods of instruction" is a challenge to the implementation of distance learning programmes. Other past studies have consistently reported similar challenges facing teachers when upgrading via the distance learning approach in some African universities (Kangai & Bukaliya, 2011; Mhishi, Bhukuvhani, & Sana, 2012; Sikwibele & Mungoo, 2009). For example, Kangai and Bukaliya (2011) in a case study conducted in Zimbabwe reported that some university programmes were disorganized and failed to provide the support needed for teacher trainees. For instance, the absence of study materials, books and journals and internet connectivity, libraries without books, the lack of capacity to supervise teacher trainees and little political will by the government to support distance learning programmes all contributed to the ineffectiveness of distance learning education. Despite the good intentions of the Tanzanian Government to support licensed science teachers through school-based professional development and distance learning, these programmes have been ineffective.

6.5 Establishment of PLCs of teachers

This discussion is based on the fourth research question

iv. What factors could facilitate a sustainable establishment of professional learning communities of licensed science teachers in Tanzania?

The participants stated that the establishment of PLCs of teachers in the Tanzanian context basically requires the availability of funds, a resource centre for teachers to meet for professional development training, learning resources, good school leadership and experts to facilitate training. They felt that if these issues are addressed, the establishment of sustainable PLCs of teachers in Tanzania would probably succeed. This finding suggests that current professional development training is not well funded by the Tanzanian Government as most participants blamed the Government for this perceived lack of support for in-service teacher professional development. Similar sentiments are echoed in previous studies such as those by Kruse et al. (1994) and Louis, Marks, and Kruse (1996), who argued that the growth of a school-based learning community depends on two main conditions: first, structural conditions such as time for teachers to meet and talk, a schools' physical proximity that supports collaboration, interdependence in teaching roles, efficient communication structures within school and teachers' empowerment; and second, social resources, which are linked to teachers' openness to improvement, their trust and respect of individual differences, teachers with knowledge and skills to share, supportive leadership and socialization among new and experienced teachers (Kruse et al., 1994; Louis et al., 1996). However, neither licensed science teachers nor educational officers in this study were able to identify what Kruse et al. (1994)

described as ‘critical elements of a strong professional learning community’. They were unable to identify the critical elements that facilitate the sustainability of school-based PLCs of teachers which include: shared norms and values about teaching and student learning, a focus on student learning, teachers’ collaboration, de-privatized teaching practice, and the existence of reflective dialogue among teachers (Kruse et al., 1994; Louis et al., 1996). However, the licensed science teachers in this study felt that the establishment and sustainability of school-based PLCs in the context of Tanzanian community secondary schools needed support from a knowledgeable facilitator who would guide them in their school. Melville and Yaxley (2009) agree, and argue that “access to external expertise appears to be a prerequisite for teachers to move towards inquiry-based science teaching, as teachers require support” (p. 363).

In summary, this study’s finding indicated that the establishment of school-based PLCs of teachers in the context of Tanzanian community secondary schools, schools need financial and material support, such as a meeting centre to share knowledge and expertise, and to receive support from experienced mentors. The knowledge accumulated by this study concerning licensed science teachers’ PCK needs, the challenges they face in teaching students using learner-centred teaching methods, the lack of school-based support for licensed science teachers and factors that hinder the establishment of PLCs of teachers resulted in the design of a PDI, the impact of which is discussed in the next section.

6.6 Effectiveness of professional development in enhancing licensed science teachers' PCK

The discussion in this section is based on the fifth and sixth research questions

v. How do licensed science teachers in Tanzania perceive the effectiveness of the PDI developed and used in this study?

vi. How effective is the professional development programme implemented in meeting licensed teachers' professional learning needs?

The findings have shown that the PDI, informed by the tenets of the situativity theory and incorporating key features of effective professional learning, enhanced licensed science teachers' PCK. This professional learning had a positive impact on teachers' classroom practice, particularly their ability to teach students using learner-centred teaching methods, despite the difficulties they faced such as shortages of teaching and learning materials and large classes. The effectiveness of the PDI was reflected in the changes observed in classroom practice as the licensed science teachers demonstrated a paradigm shift from their old transmissive teaching methods to learner-centred teaching. The study found that when lesson observations were pre-planned and teachers knew in advance that they would be observed, their lessons were better organized and classroom teaching was more interactive with greater use of locally improvised teaching and learning materials. This finding implied that when teachers pre-planned their lessons they could overcome barriers that previously constrained their use of learner-centred instruction and their effectiveness in the classroom, such as shortage of teaching and learning materials, books, a laboratory environment, consumables and large class sizes. This study provides preliminary evidence that when PDI is underpinned by the situativity theory, which is an extension of the social constructivist theory (Durning & Artino, 2011; Schunk, 2012; B. Wilson & Myers, 2000), it may effectively meet the PCK needs of teachers who have missed out on pre-service teacher education like the Tanzanian licensed science teachers.

Previous studies agree that PLCs effectively foster teachers' professional knowledge and improves their classroom practice (Borko & Koellner, 2008; Daley, 2001; Lave & Wenger, 1991; Little, 2002; Owen, 2004; van Es, 2012). This study's findings suggests that when PDI is contextualized in teachers' working environment, that engages teachers in an activity they believe is authentic to their profession and involves teachers in a collaborative community it facilitates teachers' construction of knowledge and enhances their PCK development (Anderson, Greeno, Reder, & Simon, 2000; Borko & Koellner, 2008; Ghefaili, 2003). Thus, for professional development to have an impact on teachers' practices, Opfer and Pedder (2011) argued that "one must consider what sort of local knowledge, problems, routines, and aspirations shape and are shaped by individual practices and beliefs" (p. 379).

Although student achievement as a result of the PDI was not directly evaluated in this study, the licensed science teachers categorically reported that the intervention had had a positive impact on student learning in terms of interaction, that is, student-student interaction and teacher-student interaction during the lesson. More importantly, students' absenteeism from science and mathematics classes dropped as students appeared more interested in the subjects as a result of teachers using the learner-centred instructional strategies they had learnt during the PDI. Focus group discussions with the students provided promising evidence of the impact of professional development (as they experienced the impact of the teachers' enhanced PCK after the PDI). The students reported that the teachers had been using more learner-centred instruction in science and these views were also confirmed during the classroom observation. This change in students' learning disposition suggests that the teachers had put into practice the new learner-centred teaching methods they had learnt. This finding concurs with previous work by Nunokawa (2012) who reported that after teachers had participated in the professional development training they felt more confident in their ability to implement the new instructional strategies gained from the professional development and this also had a positive effect on student learning. Other previous studies also reported that students of teachers who had participated in the professional development outperformed students whose teachers had not participated in the professional development training (Borman, Gamoran, &

Bowdon, 2008). However, Borman et al. (2008) reported that students of teachers who have participated in professional development do not necessarily do better in science because sometimes experienced teachers do not use new skills and supported the intervention as it challenges their traditional teaching practice. However, the literature consistently supports the notion that a PDI that is carefully planned, by involving teachers in their own needs assessment and conducted over a significant number of hours, allows teachers to enter into discussion, to put into practice what they learnt in the workshop, to experience school-based peer coaching within the same school or department and to share practices (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 2001; Guskey, 2000; Opfer & Pedder, 2011; van Es, 2012; Wayne, Yoon, Zhu, Cronen, & Garet, 2008).

The PDI employed in this work persuaded teachers about the value of establishing school-based PLCs of teachers. The licensed science teachers expressed the opinion that working in a professional community of teachers had helped to improve their PCK and trust amongst themselves in sharing their classroom practices. The licensed science teachers' impressions of PLCs were positive and they felt belonging to a PLC had contributed to an improvement in their classroom practices. Importantly, the culture of teachers working as a community of learners in the schools was evolving, as teachers started teaching and sharing their practices with others as a result of PDI. Past studies have indicated that teachers value collegial participation, because it provides them with the opportunity to work together as a staff and discuss their teaching experience by integrating the new knowledge gained from training (Little, 2002; Till, Ferkins, & Handcock, 2011; van Es, 2012). Headmasters, district education officers and other teachers in the study schools asked if this training, in particular the concept of PLCs of teachers, could be provided for the whole school. However, they felt that the lack of an experienced resource person or facilitator in their schools was a barrier to implementing the skills gained from PDI. Thus, for their PLCs of teachers to be sustainable, the participants in this study argued for the presence of an experienced mentor to support teachers in their use of the new skills gained from the PDI.

Despite the promising evidence that professional development improved licensed science teachers' professional skills, there was still the need to strengthen teachers' training in the construction of tests and examinations of high quality that test students' higher-level cognitive skills. Many of their examinations still contained English grammatical errors. This study suggests a number of reasons for this finding. First, test and examination construction was not part of teachers' daily routine activities like teaching, and so was given less attention by teachers. Second, teachers prepared lower-level examination items that tested factual information because they required less time to mark given the issue of large classes. Third, teachers' proficiency in English was limited and schools did not have qualified English teachers. Therefore, English was not integrated into daily professional practice to improve teachers' English literacy.

The PDI helped to enhance licensed science teachers' PCK components of orientation to science teaching, knowledge of instructional strategies, knowledge of assessment, knowledge of leaners and their characteristics and having some understanding of the science curriculum. The licensed science teachers' classroom practice showed a positive improvement as they have adopted learner-centred pedagogy. Perhaps the strongest impact of the PDI was the establishment of teachers' PLCs, which affected their beliefs and practices in teaching science by moving them towards learner-centred teaching strategies, as recommended in the Tanzanian science curriculum. The adoption of a PLC culture in the Tanzanian community secondary schools in this study provided promising evidence that the professional learning needs of unqualified Tanzanian licensed science teachers can be enhanced while they are still working. The key outcomes of the PDI reported in this study were:

- enhancement of teachers' PCK, which had a positive impact on student learning;
- paradigm shift of teachers participating in this study from their use of traditional teacher-centred teaching methods towards learner-centred teaching methods; and

- evolution of a culture of teachers working as a community of practice where teachers valued the sharing of practices.

Therefore, the success of PLCs in this study provides a light for other countries, which have used the alternative route to teacher recruitment that precluded pre-service teacher education, that these teachers' PCK needs can be met. The next chapter provides concluding remarks including the implications for policy makers and teacher education practice, and the limitations and suggestions for possible further research arising from this research.

CHAPTER 7
IMPLICATIONS, LIMITATIONS AND CONCLUSIONS

7.1 Introduction

This chapter provides the implications, conclusions, and the limitations of the study. This study aimed to investigate the classroom practice of untrained/unqualified ‘licensed science teachers’ recruited in Tanzania through the alternative teacher recruitment approach to determine their professional learning needs, in particular those relating to PCK. The findings from the exploration of their professional learning needs provided evidence that the PCK components of these teachers who had not received traditional university-based pre-service teacher education were underdeveloped. As a result, a professional development initiative underpinned by the situativity theory was designed and implemented in this study for the purpose of improving the licensed teachers’ classroom practice, and especially meeting their PCK needs. The findings indicated that the teachers’ classroom teaching practice was positively enhanced and teachers were inspired by the PDI believing that it had enriched their PCK. This study provides a valuable understanding of what the professional learning needs of licensed science teachers might be and how these needs could be met in order to improve licensed teachers’ effectiveness in the classroom.

Since the intention of this study was to improve unqualified licensed science teachers’ classroom practice, applying the outcomes of this study in other contexts is of paramount importance, in particular informing political decisions relating to recruiting teachers without pre-service teacher training. Although the findings of the case studies cannot be generalized, some aspects could be applied to other similar contexts to improve the classroom practice of teachers recruited using alternative route pre-service teacher training. This claim can be made because this interpretive inquiry has taken into careful consideration criteria such as the transferability, confirmability, dependability and credibility of the findings to enhance the trustworthiness of the study (Cutcliffe & McKenna, 1999, 2004; Guba & Lincoln, 1982; Tracy, 2010). For example, the inquiry was prolonged, data collection instruments were triangulated, and participants validated the data and analysis, all of which served to enhance the credibility of the inquiry (Graneheim & Lundman, 2004). Similarly, to enhance the transferability of the findings to other settings, the participants were purposively selected, and the inquiry procedures and context described thoroughly (Bitsch, 2005; Tobin & Begley, 2004). In addition, the data and its interpretation were audited by the participants, and the researcher kept a reflexive journal to enhance the confirmability and dependability of the inquiry (Guba, 1981; Guba & Lincoln, 1982; Li, 2004).

Given the current teacher shortage in Tanzania and the inability of its teacher education institutions to train enough teachers to staff the country's growing secondary education sector, the ongoing use of unqualified licensed science teachers in Tanzanian community secondary schools is inevitable with no obvious alternative in the near future. This study's findings have shown that the use of unqualified teachers with underdeveloped PCK has a negative impact on their students' learning as these teachers teach and test lower-level cognitive skills. However, this study provided promising evidence that their underdeveloped PCK could be enriched using professional learning and development that assessed teachers' needs and allowed the sharing of knowledge and skills in the school setting. In other words, this study provides a number of ideas that could be used by educational experts and policy makers to improve the teaching skills of untrained licensed science teachers.

7.2 Implications for teacher training institutions

The findings of this study suggest that the Open University of Tanzania (OUT) programme, designed to help licensed science teachers upgrade their qualification to bachelor degree in teacher education failed to address the professional learning needs of licensed science teachers working in rural community secondary schools. It lacked a supportive structure and was under resourced, and was essentially reported ineffective. The classroom practice of some licensed science teachers in the study who were enrolled and studying at the OUT was no different from that of other participants who were not enrolled in the programme. All teachers used transmissive teacher-centred pedagogy. These challenges facing the OUT programme provide a wake-up call for providers, suggesting they need to re-evaluate the way in which their programmes are conducted to ensure that elements of learner-centred pedagogy are present and strongly promoted. Perhaps most importantly, the OUT needs to address those factors that hinder the delivery of teaching materials to licensed science teacher working in rural community secondary schools. This present study findings explicitly indicated that lack of resources was a major barrier affected licensed science teachers' professional growth through OUT and was unsuccessfully in enhancing their PCK needs. Therefore, this study recommends that the Tanzanian Government to redirect more resources to support licensed science teachers studying at the OUT in particular to provide teaching and learning resources, such as availability of internet, books and funds to support teachers working in rural community secondary schools. This support could enhance the availability of mobile internet facilities, computers, books, and affordable transport for licensed science teachers working in rural community secondary schools across the country.

7.3 Implications for policy and practice

This study's findings have implications for educational policy makers, administrators and school leaders. The findings suggest that the licensed science teachers' PCK in the study was generally weak, and they were unable to use learner-centred teaching methods. Since the recruitment of teachers via the alternative recruitment approach was a political decision, it is recommended that in the future political decisions affecting a profession such as teaching should be guided by research. The findings have indicated that the decision made by political elites to recruit untrained teachers has negative implications for the Tanzanian education system, as teachers recruited in this way were unable to effectively teach science and impart higher-order cognitive skills. Therefore, policy makers and educational administrators should play a key role in advising the political elites on the impact of such political decisions on matters relating to professions, in particular education, which is a driver of the country's economic and social development. The quality of education in any country depends on the quality of its teachers (Organisation for Economic Co-operation and Development, 2012), because "the quality of an education system cannot exceed the quality of its teachers and principals, since student learning is ultimately the product of what goes on in classrooms" (Organisation for Economic Co-operation and Development, 2010, p. 4). This relationship means that using poor quality teachers inevitably results in poor quality education and students with poor knowledge and skills. Thus, in order to "provide high-quality education to the broader population, education systems must recruit their teachers from the top of the higher education pool" (Organisation for Economic Co-operation and Development, 2012, p. 22).

Learner-centred instructional strategies are key to effective pedagogy and the language of instruction was pointed out by licensed science teachers in this study as a barrier to using such strategies. The study has indicated that the lack of proficiency in English has prevented both teachers and students from communicating their ideas effectively during the instructional process. The current practice in Tanzania is that Kiswahili is the medium of instruction in pre-primary and primary schools. English is introduced as a subject in year 9, which then becomes the medium of instruction in secondary education. This practice is a barrier for student learning because this sudden change from Kiswahili to English usage at secondary school level challenges students' learning of science. Students are engaged in two tasks in the science classroom: learning the English language, and learning their science subjects. Therefore, this study recommends to the Tanzanian Government through the MoEVT that it reviews the current language of instruction policy where Kiswahili is used as the medium of instruction in pre-primary and primary schools and English in secondary schools. This study points out that the sudden shift from Kiswahili to English as the medium of instruction in secondary schools is one of the root causes of teachers' and students' limited ability to converse in English during instruction, as both students and teachers lack a strong foundation in English at pre-primary and primary schools. This study recommends that English be introduced as the medium of instruction as early as possible, that is, from pre-primary school throughout all levels of education. This practice would help teachers and students acquire a strong foundation in English in their early childhood schooling. Also, teachers who are already working in schools need English literacy training to enhance their proficiency in the language, since this weakness in English was identified in this study as a barrier to the construction of reliable and valid tests and examinations by licensed science teachers. Such English literacy training could be introduced into national professional development training programmes to enhance teachers' English literacy in all the schools. Although there is a lot of literature (e.g. Brock-Utne, 2012b; Brock-Utne & Holmarsdottir, 2004; Qorro, 2006; Senkoro, 2005; Vuzo, 2010) that proposes the use of Kiswahili as the medium of instruction in all levels of education in Tanzania, this thesis is of the view that a total change in the medium of instruction from English to Kiswahili would affect Tanzanian citizens' mobility in the East African community and elsewhere in the world. In this wider community member states use English as the medium of instruction because it is regarded as the key language required by its people to access world employment opportunities (Vavrus, 2002). Moreover, English is also reported to be the international language of business, science and technology (Yip, 2003). Although Kiswahili is the most widely spoken language in Tanzania, in the Tanzanian context it is a second language for pupils. Tanzania has more than 125 languages, which means that children learn their mother tongue first at home and then Kiswahili at school (Kitta, 2004).

School-based professional learning and development for licensed science teachers is lacking in Tanzania, as was noted in this study. Given that licensed science teachers did not receive appropriate pre-service teacher education and lack school-based professional development support, the MoEVT needs to urgently introduce targeted school-based professional development programmes, such as mentoring or peer coaching, to help induct novices and unqualified licensed science teachers into the culture of classroom teaching. School-based professional development is strongly recommended for schools in rural areas because it is conducted in school environment unlike traditional professional development that requires teachers to travel for workshop sessions. It is also is less expensive. Effective school-based professional development support will enable licensed science teachers to learn learner-centred methods of teaching that should help to improve their teaching improve student learning outcomes. This move also requires the MoEVT to provide training for mentors and support for schools by providing the required resources. In addition, school leaders should also provide a conducive learning environment for collaboration that will enable experienced teachers to share their teaching practice knowledge with novice teachers in their schools by encouraging the development of professional learning communities (PLCs) in their schools. This study also pointed out that the ongoing success of PLCs in community secondary schools requires support from experienced facilitators. There are two clear reasons why experienced facilitators are important for the establishment of teachers' learning communities in the context of Tanzanian community secondary schools. First, licensed science teachers lack sufficient subject content knowledge and pedagogical knowledge to teach effectively, and so have little to contribute and share within a PLC of teachers. Second, few community secondary schools have experienced science teachers to support novice teachers in meeting their professional learning needs. Given these challenges, if PLCs are to be successful support networks for licensed science teachers, then external professional learning support from experienced mentors is essential for achieving meaningful gains in their PCK.

Classroom observations revealed that some licensed science teachers were allocated three subjects to teach per term, more than the MoEVT guidelines that require teachers to specialize in two subjects. For example, some teachers were found to be teaching three subjects - physics, chemistry and mathematics, or physics, chemistry and biology. This overloading of subjects, compounded by licensed science teachers' inadequate pedagogical and subject content knowledge and their lack of specialization in teaching subjects caused many lessons to be superficial. Therefore, this study recommends that leaders in Tanzanian secondary schools allocate a maximum of two subjects to licensed science teachers because this limit will help them to deeply immerse themselves in their respective teaching subjects - as teaching more than two teaching subjects at secondary level results in teacher's partial preparation of their subjects. Schools are required to employ more teachers to address the overloading of unqualified teachers in Tanzanian community secondary schools.

Despite the evidence of the promising impact of professional development on the enrichment of licensed science teachers' PCK, the study findings have shown that the intervention did not have a deep impact on their ability to construct test and examination items of high quality that would test students' higher-order cognitive skills. The post-intervention tests and examinations remained unchanged as many test items were found to be still assessing lower-level cognitive skills. Professional development planners need to address this challenge by integrating test and examination construction into teachers' daily activities during school-based professional development training. Also, the study recommends to schools management to use teacher communities to develop bank questions for each subject at departmental level so that teachers could use these questions as a guides for constructing tests when necessary.

7.4 Implications for further research

This study's findings provided evidence that the underdeveloped PCK of teachers recruited using the alternative route, such as licensed science teachers, could be improved using professional development. The licensed science teachers greatly appreciated professional development that used collaborative activities, such as the sharing of classroom teaching practices within a learning community of teachers. They viewed such learning communities as a promising solution to their underdeveloped PCK while working in schools. They felt that the intervention had improved their classroom practice, in particular skills for teaching science using learner-centred pedagogies. To gain a deeper understanding of alternative approaches to teacher recruitment the following recommendations for further study are made:

- a study similar to this present study should be carried out that would involve a larger sample of licensed science teachers across all 25 regions of Tanzania mainland. A larger-scale study may help reveal the extent of any negative impact of using the licensed teacher approach to teacher recruitment in the Tanzanian education system and provide more comprehensive insights into the professional learning needs of these teachers across the country. Also larger-scale studies would facilitate more generalisability of the findings in this area of the alternative route to teacher recruitment in the context of developing countries.

- A further study is also recommended to evaluate the impact of licensed science teachers' participation in professional development training on students' academic achievement and on the achievements of students whose licensed teachers had not received the intervention. Such a study would provide evidence of whether or not licensed science teachers' participation in professional development has a positive impact on students' learning outcomes.
- The findings from this study point to a mismatch between the participating licensed science teachers' classroom practice and their views on the use of learner-centred instructional strategies. They claimed to use learner-centred teaching methods because their Form 1 and 2 students do not like teacher-centred approaches, while observation of their practice indicated that in fact they rarely use learner-centred teaching methods. Therefore, a further inquiry is recommended to examine licensed science teachers' perception and students' perception of the effectiveness of the use learner-centred teaching methods. Exposing teachers' beliefs may provide the reasons why they still prefer using teacher-centred teaching methods despite being discouraged by the science education curriculum.

7.5 Limitations of the study

This interpretive inquiry employed a case study approach because it allowed the researcher to conduct a holistic investigation into phenomena to provide a more complete picture of the problem in its natural setting, which other research methods could not do easily. The case study approach investigated the classroom practices of a few participants in order to obtain in-depth information on the phenomena under investigation. This study probed licensed science teachers' views and classroom practices in four case study schools and these findings were further informed by interviewing their immediate supervisors (headmasters, district and ward education officers and the regional school inspector). However, the study involved a small number of participants in rural community secondary schools, which do not necessarily represent the entire cohort of licensed science teachers in Tanzania - given that the country is huge with diverse cultures and environments and large differences in regional, social and economic development. The small sample of six teachers, two headmasters, two district education officers, one ward education officer and one school inspector thus precludes the possibility of generalizing the findings to the entire population of licensed science teachers in Tanzanian community secondary schools. Despite these limitations, the findings provide insights or act as an 'eye-opener' for educational experts into what is taking place in classes taught by licensed science teachers in Tanzanian community secondary schools.

Another limitation that may have affected the study's findings was the frequent changes to the licensed teachers' teaching subjects caused by headmasters allocating them different subjects each term. These frequent changes are likely to have affected the consistency of applying new skills gained from the PDI. This complication could have been avoided if the research design had included school headmasters/mistresses in the professional development training. Any future study should include such school personnel in the PDI to facilitate the provision of a supportive environment in which licensed science teachers could practise their newly gained skills in the whole school setting.

Finally, this study's findings indicate that the subject content knowledge of licensed science teachers was inadequate, which affected their ability to design learning activities that engage students in higher-order learning. This study did not go into the details of meeting the specific subject content knowledge needs of individual licensed science teachers, because addressing such needs would require four science specialists in the subjects of physics, chemistry, biology and mathematics. The PDI put more emphasis on improving teachers' classroom practice.

However, during PDI process licensed science teachers content knowledge needs were indirectly enhanced through sharing classroom teachers practice via community teachers. Previous literature strongly supports that in-service professional development programmes that involve teachers into sharing of ideas (e.g subject-specific topic discussion) as learning community helps the development of their PCK and content knowledge (Cochran, King, & DeRuiter, 1991; Magnusson et al., 1999). The work by Magnusson et al. (1999) and provided a conclusive recommendation to teacher educators that:

> "… we must develop ways for teachers and teacher educators to share subject-specific information for teaching science as a support for teachers in extending their new understandings and practices to topic areas beyond those which might have been the focus of particular teacher education programs. The increasing availability of telecommunications in the schools provides one possible strategy for addressing this need. For example, teachers could email one another to share ideas and experiences while teaching similar topics. (Magnusson et al., 1999, p. 124)

In addition, recent studies has reported that teachers working collaboratively as a PLC is strongly reported in the literature as a panacea of enhancing teachers with limited SMK (Doerr & Britton, 2010; E. Lee, Brown, Luft, & Roehrig, 2007). Doerr and

Britton (2010) argued that "participation in PLCs can successfully engage teachers in discussion about content knowledge or knowledge about how to teach it (PCK), positively impacting their understanding of or preparedness to teach content, or attitudes toward teaching methods" (p. 7). This implies that collaborative teachers' team work helps to enhance their limited subject matter knowledge and they subsequently develop their own PCK. Despite this view that teachers sharing of their skills and working as PLC helps to enhance their subject content knowledge, if this study were to be repeated the design of the professional development should ideally involve experts in specific subjects that would enable teachers to improve their subject content knowledge.

7.6 Conclusions

This study sought to find out the professional learning needs of untrained licensed science teachers in Tanzania, in particular those relating to PCK, and the strategies for supporting their PCK development. Licensed science teachers' professional learning needs were explored and the study identified that their PCK was underdeveloped. The study found that the licensed science teachers' classroom teaching practice embraced the teacher-centred transmissive approach that perpetuates the memorization of facts and the acquisition of lower-level cognitive skills. Their weak PCK meant the licensed science teachers struggled to teach science effectively using learner-centred teaching methods. Although it was suggested by the Tanzanian Government that licensed science teachers will receive the "… substantial support and in-service training to avoid the problems that arose in the 1970s with the UPE teachers" (Carr-Hill & Ndalichako, 2005, p. xiii), which was reported as one of the key the reasons for the fall in the quality of education in Tanzanian primary schools, this support largely failed to materialize. Unfortunately, there has been no substantial in-service training for licensed science teachers and the OUT programme that was intended to enhance their professional skills was found to be largely ineffective.

To improve the teaching practice of the licensed teachers in the study an intervention was set up and implemented as a strategy for addressing their learning needs. The licensed science teachers strongly agreed that PDI had changed their orientation to science teaching and their classroom practice was observed to be significantly improved. Therefore, with regard to the PDI, the study concludes:

- The licensed teachers were encouraged to change their belief in teacher-centred pedagogy and use learner-centred teaching methods. As a result, their classroom practice was more learner-centred and they asked more formative assessment questions;
- Their students were more interactive and a culture of dialogue began to evolve between the students and their teachers during the teaching and learning process. This culture of dialogue has changed the licensed teachers' belief that students are receivers of knowledge from teachers; and
- The inclusion of the licensed teachers in identifying their professional learning needs and in practising and reflecting on the learned skills as a community of learners was successful in helping the development of school-based PLCs of teachers. Evidence that emerged from this study suggests that the teachers were inspired by working collaboratively, which had created the opportunity for them to share their teaching practices, resulting in the improved learning of students in their classrooms.

Most significantly, the insights provided by this study's participants into teacher development via school-based PLCs should be used by education policy makers and administrators to improve licensed science teachers' PCK. This study findings recommends that PLCs of teachers with experts support, and sustained with schools leadership (headmasters/mistresses, district educational officers) involvement offers a way forward for improving PCK of many untrained licensed teachers currently working in Tanzanian rural community secondary schools. Continued use of untrained licensed science teachers without enhancing their underdeveloped PCK will continue to accelerate the deterioration in the quality of education in Tanzania and undermine curriculum goals relating to students acquiring enquiring minds in relation to science.

REFERENCES

Aaronson, D., Barrow, L., & Sander, W. (2007). Teachers and student achievement in the Chicago public high schools. *Journal of Labor Economics, 25*(1), 95-135.

Abe, N. (2011). How the brain shapes deception. *The Neuroscientist, 17*(5), 560-574. doi: 10.1177/1073858410393359

Abell, S. K., Rogers, M. A. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education, 20*(1), 77-93. doi: 10.1007/s10972-008-9115-6

Adams, P. E., & Krockover, G. H. (1997). Beginning science teacher cognition and its origins in the preservice secondary science teacher program. *Journal of Research in Science Teaching, 34*(6), 633-653. doi: 10.1002/(sici)1098-2736(199708)34:6<633::aid-tea6>3.0.co;2-o

Adedoyin, O. O. (2011). The impact of teachers' in-depth pedagogical mathematical content knowledge on academic performance: As perceived by Botswana junior secondary school pupils. *European Journal of Educational Studies, 3*(2), 277-292.

Adler, E. S., & Clark, R. (2008). *How it's done: An invitation to social research* (3rd ed.). Belmont, CA: Wadsworth.

African Development Bank. (2007). *Education II project: Project completion report-United Republic of Tanzania*. Retrieved from http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/ADF-BD-IF-2007-141-EN-TANZANIA-PCR-EDUCATION-II-PROJECT.PDF

Akiba, M., LeTendre, G. K., & Scribner, J. P. (2007). Teacher quality, opportunity gap, and national achievement in 46 countries. *Educational Researcher, 36*(7), 369-387. doi: 10.3102/0013189x07308739

Altinyelken, H. K. (2010). Pedagogical renewal in Sub-Saharan Africa: The case of Uganda. *Comparative Education, 46*(2), 151-171. doi: 10.1080/03050061003775454

Alton-Lee, A. (2003). *Quality teaching for diverse students in schooling: Best evidence synthesis iteration (BES)*. Retrieved from http://www.educationcounts.govt.nz/publications/series/2515/5959

Anderson, J. R., Greeno, J. G., Reder, L. M., & Simon, H. A. (2000). Perspectives on learning, thinking, and activity. *Educational Researcher, 29*(4), 11-13. doi: 10.3102/0013189x029004011

Anney, V. N. (2007). *Local teaching materials (LTM) as an alternative strategy for improving chemistry teaching in community secondary schools (CSS) in Tanzania.* (Unpublished master's thesis), University of Dar es Salaam, Dar es Salaam, Tanzania.

Ary, D., Jacobs, L. C., Razavieh, A., & Sorensen, C. K. (2010). *Introduction to research in education* (8th ed.). New York, NY: Hult Rinchart & Wiston.

Audrey-marie, M. S., & DeStefano, J. (2008). *Expanding secondary education for Sub-Saharan Africa: Where are teachers?* Retrieved from http://www.equip123.net/docs/2-SecondaryExapansionSSA WP.pdf

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education, 27*(1), 10-20. doi: 10.1016/j.tate.2010.08.007

Avramidis, E., & Smith, B. (1999). An introduction to the major research paradigms and their methodological implications for special needs research. *Emotional and Behavioural Difficulties, 4*(3), 27-36. doi: 10.1080/1363275990040306

Baeh, M. (2005). *Distinctions between assessment and evaluation*. http://pcrest.com/LO/PA/PAI_files/PAI/Kettering_PAS_May_31_June_1_2007/Program%20Assessment%20Handbook.pdf#page=11

Baeten, M., Kyndt, E., Struyven, K., & Dochy, F. (2010). Using student-centred learning environments to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness. *Educational Research Review, 5*(3), 243-260. doi: 10.1016/j.edurev.2010.06.001

Bantwini, B. (2004). District professional development models as a way to introduce primary-school teachers to natural science curriculum reforms in one district in South Africa. *Journal of Education for Teaching, 35*(2), 169-182. doi: 10.1080/02607470902771094

Barab, S. A., & Duffy, T. (2000). From practice fields to communities of practice. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25-56). London, England: Lawrence Erlbaum Associates.

Barclay, R., Feistritzer, E., Grip, R., Haar, C., Seaton, G., Sherman, S., & Stone, M. (2007). *The New Jersey alternate route program: An analysis of the perspectives from alternate route teachers, alternate route instructors, and alternate route mentors*. Retrieved from http://www.nj.gov/education/educators/license/research/alternate.pdf

Barrett, A. M. (2007). Beyond the polarization of pedagogy: Models of classroom practice in Tanzanian primary schools. *Comparative Education, 43*(2), 273-294. doi: 10.2307/29727829

Bartell, C. A. (2004). *Cultivating high-quality teaching through induction and mentoring*. Thousand Oaks, CA: Corwin Press.

Baxter, J., & Eyles, J. (1997). Evaluating qualitative research in social geography: Establishing 'rigour' in interview analysis. *Transactions of the Institute of British Geographers*, *22*(4), 505-525. doi: 10.1111/j.0020-2754.1997.00505.x

Becker, S., & Bryman, A. (2004). *Understanding research for social policy and practice: Themes, methods and approaches*. Bristol, England: Policy Press.

Beese, J., & Xin Liang. (2010). Do resources matter? PISA science achievement comparisons between students in the United States, Canada and Finland. *Improving Schools, 13*(3), 266-279. doi: 10.1177/1365480210390554

Behi, R., & Nolan, M. (1995). Ethical issues in research. *British Journal of Nursing, 12*(4), 712-716.

Bernard, H. R. (2000). *Social research methods: Qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Berry, A., Loughran, J., & Van Driel, J. H. (2008). Revisiting the roots of pedagogical content knowledge. *International Journal of Science Education, 30*(10), 1271 - 1279. doi: 10.1080/09500690801998885

Birkeland, S. E., & Peske, H. G. (2004). *Literature review of research on alternative certification*. Retrieved from http://www.teach-now.org/NEAFullText.pdf

Bishop, R., Berryman, M., Cavanagh, T., & Teddy, L. (2009). Te Kotahitanga: Addressing educational disparities facing Māori students in New Zealand.

Teaching and Teacher Education, 25(5), 734-742. doi: 10.1016/j.tate.2009.01.009

Bissaker, K. (2009). *The processes and outcomes of professional learning in an innovative school: The construction of an explanatory model* (Doctoral dissertation), Flinders University, Adelaide, Australia. Retrieved from http://theses.flinders.edu.au/uploads/approved/adt-SFU20100309.162227/public/02whole.pdf

Bitsch, V. (2005). Qualitative research: A grounded theory example and evaluation criteria. *Journal of Agribusiness, 23*(1), 75-91.

Blaikie, N. (2007). *Approaches to social enquiry: Advancing knowledge* (2nd ed.). Cambridge, England: Polity Press.

Blaikie, N. (2010). *Designing social research: The logic of anticipation* (2nd ed.). Cambridge, England: Polity Press.

Bloom, B. S. (1956). *Taxonomy of educational objectives – handbook 1: Cognitive domain*. London, England: Longman.

Boikhutso, K. (2010). The theory into practice dilemma: Lesson planning challenges facing Botswana student-teachers. *Improving Schools, 13*(3), 205-220. doi: 10.1177/1365480210385668

Borg, W. R., Gall, J. P., & Gall, M. D. (1993). *Applying educational research: A practical guide* (3rd ed.). New York, NY: Longman.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15. doi: 10.3102/0013189x033008003

Borko, H., & Koellner, K. (2008, March). *Situativity: A theoretical lens for designing and studying programs of professional development*. Paper presented at the International Commission on Mathematical Instruction Symposium, Rome, Italy. Retrieved from http://www.unige.ch/math/EnsMath/Rome2008/WG2/Papers/BORKO.pdf

Borman, G. D., Gamoran, A., & Bowdon, J. (2008). A randomized trial of teacher development in elementary science: First-year achievement effects. *Journal of Research on Educational Effectiveness,1*(4), 237-264. doi: 10.1080/19345740802328273

Borowski, A., Carlson, J., Fischer, H. E., Henze, I., Gess-Newsome, J., Kirschner, S., & Driel, J. v. (2011). Different models and methods to measure teachers' pedagogical content knowledge. http://www.esera.org/media/ebook/strand13/ebook-esera2011_BOROWSKI-13.pdf

Bouchard, T. J. (1976). Unobtrusive measures: An inventory of uses. *Sociological Methods and Research, 4*(3), 267-300. doi: 10.1177/004912417600400301

Bowen, G. A. (2009). Supporting a grounded theory with an audit trail: An illustration. *International Journal of Social Research Methodology, 12*(4), 305-316. doi: 10.1080/13645570802156196

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage.

Boyd, D. J., Grossman, P. L., Lankford, H., Loeb, S., & Wyckoff, J. (2009). Teacher preparation and student achievement. *Educational Evaluation and Policy Analysis, 31*(4), 416-440. doi: 10.3102/0162373709353129

Bozkurt, O., & Osman, N. K. (2008). Teaching about ozone layer depletion in Turkey: Pedagogical content knowledge of science teachers. *Public Understanding of Science*, *17*(2), 261-276. doi: 10.1177/0963662506071787

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi: 10.1191/1478088706qp063oa

Brendzel, S. (2005). *Strategies for successful scientific teaching*. Manheim, MD: University Press of America.

Brock-Utne, B. (2007). Language of instruction and student performance: New insights from research in Tanzania and South Africa. *International Review of Education, 53*(5-6), 509-530. doi: 10.1007/s11159-007-9065-9

Brock-Utne, B. (2012a). Language policy and science: Could some African countries learn from some Asian countries? *International Review of Education, 58*(4), 481-503. doi: 10.1007/s11159-012-9308-2

Brock-Utne, B. (2012b, October). *Where have all the policy drafts gone?* Paper presented at the International Conference on 50 Years of Kiswahili as a Language of African Liberation, Unification and Renaissance, Dar es Salaam, Tanzania.

Brock-Utne, B., & Holmarsdottir, H. B. (2004). Language policies and practices in Tanzania and South Africa: Problems and challenges. *International Journal of Educational Development, 24*(1), 67-83. doi: 10.1016/j.ijedudev.2003.10.002

Brodie, K., Lelliott, A., & Davis, H. (2002). Forms and substance in learner-centred teaching: Teachers' take-up from an in-service programme in South Africa. *Teaching and Teacher Education*, *18*(5), 541-559. doi: 10.1016/S0742-051X(02)00015-X

Brown, G. (2004). *How students learn: A supplement to the Routledge Falmer key guides for effective teaching in higher education series*. Retrieved from http://www.routledgeeducation.com/resources/pdf/how_to_learn.pdf

Brown, J. (2008). Student-centered instruction: Involving students in their own education. *Music Educators Journal, 94*(5), 30-35. doi: 10.1177/00274321080940050108

Brown, P., Friedrichsen, P. M., & Abell, S. (2009, September). *Do beliefs change? Investigating prospective teachers' science teaching orientations during an accelerated post-baccalaureate program*. Paper presented at the European Science Education Research Association (ESERA), Istanbul, Turkey. Retrieved http://resmar2t.missouri.edu/papers/Science%20Teaching%20Orientations.pdf

Brown, S., & Locke, A. (2008). Social psychology. In C. Willig & W. S. Rogers (Eds.), *The Sage handbook of qualitative research in psychology*. London, England: Sage.

Bryman, A. (2004). *Social research methods* (2nd ed.). New York, NY: Oxford University Press.

Bryman, A. (2008). *Social research methods* (3rd ed.). New York, NY: Oxford University Press.

Calabria, F. M. (1960). Characteristics of effective teachers. *Educational Research Bulletin*, *39*(4), 92-100

Carr-Hill, R., & Ndalichako, J. (2005). *Tanzania education sector situation analysis final report*. Retrieved from http://www.eddpg.or.tz/pdf/ESPR%20and%20AM/ESDP%20Situational%20Analysis%20Final%20Report%20December%202005.pdf

Carter, L. (2010). Neoliberal globalization and learner-centered pedagogies: Posing some different questions. *Canadian Journal of Science, Mathematics and Technology Education, 10*(3), 223-231. doi: 10.1080/14926156.2010.504481

Casey, S. A. (2008). *Subject matter knowledge for teaching statistical association* (Doctor of Philosophy), Illinois State University, Illinois, IL. Retrieved from https://www.stat.auckland.ac.nz/~iase/publications/dissertations/08.Casey.Dissertation.pdf

Chapman, D., & Adams, D. (Eds.). (2002). *The quality of education: Dimensions and strategies* (Vol. 5). Hong Kong, China: Asian Development Bank and Comparative Education Research Centre.

Chiang, C.-K., Chapman, H., & Elder, R. (2010). Changing to learner-centred education: Challenges experienced by nurse educators in Taiwan. *Nurse Education Today, 30*(8), 816-820. doi: 10.1016/j.nedt.2010.03.002

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s Sub-Saharan Africa. *International Journal of Educational Development, 28*(2), 195-205. doi: 10.1016/j.ijedudev.2007.04.003

Chonjo, P., O-saki, K. M., Mrutu, N., & Possi, M. (1996). *Situation analysis of science teaching in secondary schools*. Dar es Salaam, Tanzania: Ministry of Education and Culture.

Çimer, A. (2007). Effective teaching in science: A review of literature. *Journal of Turkish Science Education, 4*(1), 20-44.

Clark, J. C., & Walsh, J. (2002). *Elements of a model of effective teachers*. Retrieved from http://www.aare.edu.au/02pap/wal02220.htm

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2010). Teacher credentials and student achievement in high school. *Journal of Human Resources, 45*(3), 655-681.

Cochran, K. F., & Jones, L. L. (1998). The subject matter knowledge of preservice science teachers. In B. J. Fraser & K. G. Tobin (Eds.), The International Handbook of Science Education (Vol. 2, pp. 707-718). Dordrecht, The Netherland: Kluwer.

Cochran, K. F., King, R. A., & DeRuiter, J. A. (1991). Pedagogical content knowledge: A tentative model for teacher preparation. http://eric.ed.gov/?id=ED340683

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). London, England: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). New York, NY: Routledge.

Cohen-Vogel, L., & Smith, T. M. (2007). Qualifications and assignments of alternatively certified teachers: Testing core assumptions. *American Educational Research Journal, 44*(3), 732-753. doi: 10.3102/0002831207306752

Conner, L. (2009). Initial teacher education programmes in transition: Tensions and possibilities. *Curriculum Matters, 5,* 127-137.

Corcoran, T. B. (1995). *Helping teachers teach well: Transforming professional development*. Retrieved from http://www.cpre.org/sites/default/files/policybrief/857_rb16.pdf

Cormier, R., & Olivier, D. F. (2009, March). *Professional learning committees: Characteristics, principals, and teachers*. Paper presented at the annual meeting of the Louisiana Education Research Association, Lafayette, Louisiana. Retrieved from http://ullresearch.pbworks.com/f/Cormier_ULL_PLC_Characteristics_Principals_Teachers.pdf

Cornelius-White, J. (2007). Learner-centered teacher-student relationships are effective: A meta-analysis. *Review of Educational Research, 77*(1), 113-143. doi: 10.3102/003465430298563

Craft, H., & Bland, P. D. (2004). Ensuring lessons teach the curriculum with a lesson plan resource. *A Journal of Educational Strategies, Issues and Ideas, 78*(2), 88-94. doi: 10.3200/tchs.78.2.88-94

Creswell, J. W. (2009). *Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Crooks, T. J. (1988). The impact of classroom evaluation practices on students. *Review of Educational Research, 58*(4), 438-481. doi: 10.3102/00346543058004438

Cuddapah, J. L., & Clayton, C. D. (2011). Using Wenger's communities of practice to explore a new teacher cohort. *Journal of Teacher Education, 62*(1), 62-75. doi: 10.1177/0022487110377507

Curry, L. A., Nembhard, I. M., & Bradley, E. H. (2009). Qualitative and mixed methods provide unique contributions to outcomes research. *Circulation, 119*(10), 1442-1452. doi: 10.1161/circulationaha.107.742775

Cutcliffe, J. R., & McKenna, H. P. (1999). Establishing the credibility of qualitative research findings: The plot thickens. *Journal of Advanced Nursing, 30*(2), 374-380. doi: 10.1046/j.1365-2648.1999.01090.x

Cutcliffe, J. R., & McKenna, H. P. (2004). Expert qualitative researchers and the use of audit trails. *Journal of Advanced Nursing, 45*(2), 126-133. doi: 10.1046/j.1365-2648.2003.02874.x

Dahlkemper, L. (2001). Are alternative certification programs a solution to the teacher shortage? *The Southwest Educational Development Laboratory, 13*(2), 8-12. Retrieved from http://www.sedl.org/pubs/sedletter/v13n02/v13n02.pdf

Daley, B. J. (2000). Learning in professional practice. *New Directions for Adult and Continuing Education, 2000*(86), 33-42. doi: 10.1002/ace.8604

Daley, B. J. (2001). Learning and professional practice: A study of four professions. *Adult Education Quarterly, 52*(1), 39-54. doi: 10.1177/074171360105200104

Dall'Alba, G., & Sandberg, J. (2006). Unveiling professional development: A critical review of stage models. *Review of Educational Research, 76*(3), 383-412. doi: 10.3102/00346543076003383

Dana, T. M., Campbell, L. M., & Lunetta, V. N. (1997). Theoretical bases for reform of science teacher education. *The Elementary School Journal, 97*(4), 419-432.

Darling-Hammond, L. (1990). Teaching and knowledge: Policy issues posed by alternate certification for teachers. *Peabody Journal of Education, 67*(3), 123-154.

Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching*. Kutztown, PA: National Commission on Teaching & America's Future.

Darling-Hammond, L. (2000a). How teacher education matters. *Journal of Teacher Education, 51*(3), 166-173. doi: 10.1177/0022487100051003002

Darling-Hammond, L. (2000b). *Solving the dilemmas of teacher supply, demand, and standards: How we can ensure a competent, caring, and qualified teacher for every child*. Retrieved from http://www.nctaf.org/documents/supply-demand-standards.pdf

Darling-Hammond, L. (2000c). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives, 8*(1), 1-44.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education, 57*(3), 300-314. doi: 10.1177/0022487105285962

Darling-Hammond, L., & McLaughlin, M. W. (1996). Policies that support professional development in an era of reform. In M. W. McLaughlin & I. Oberman (Eds.), *Teacher learning: New policies, new practices* (pp. 202-218). New York, NY: Teachers College Press.

Darling-Hammond, L., & McLaughlin, M. W. (2011). Kappan classic: Policies that support professional development in an era of reform. *Phi Delta Kappan, 92*(6), 81-92.

Darling-Hammond, L., & Richardson, N. (2009). Research review/teacher learning: What matters? *How Teachers Learn, 66*(5), 46-53.

Darling-Hammond, L., & Youngs, P. (2002). Defining “highly qualified teachers”: What does “scientifically-based research” actually tell us? *Educational Researcher, 31*(9), 13-25. doi: 10.3102/0013189x031009013

Darling-Hammond, L., Berry, B., & Thoreson, A. (2001). Does teacher certification matter? Evaluating the evidence. *Educational Evaluation and Policy Analysis, 23*(1), 57-77. doi: 10.3102/01623737023001057

Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education*, *53*(4), 286-302. doi: 10.1177/0022487102053004002

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Dallas, TX: National Staff Development Council.

Dash, N. K. (2005). *Selection of research paradigm and methodology: Online research methods resources for teachers and trainers*. Retrieved from http://www.celt.mmu.ac.uk/researchmethods/Modules/Selection_of_methodology/index.php

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651. doi: 10.3102/00346543076004607

De Jong, O., & Van Driel, J. H. (2004). Exploring the development of student teachers' PCK of the multiple meanings of chemistry topics. *International Journal of Science and Mathematics Education, 2*(4), 477–491. doi: 10.1007/s10763-004-4197-x

de la Sablonnière, R., Taylor, D. M., & Sadykova, N. (2009). Challenges of applying a student-centered approach to learning in the context of education in Kyrgyzstan. *International Journal of Educational Development, 29*(6), 628-634. doi: 10.1016/j.ijedudev.2009.01.001

Dee, T. S., & Cohodes, S. R. (2008). Out-of-field teachers and student achievement: Evidence from matched-pairs comparisons. *Public Finance Review, 36*(1), 7-32. doi: 10.1177/1091142106289330

Denscombe, M. (2007). *The good research guide: For small-scale social research projects* (3rd ed.). Berkshire, England: McGraw-Hill.

Denscombe, M. (2010). *The good research guide: For small-scale social research projects* (4th ed.). Berkshire, England: McGraw-Hill.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (1994). *Handbook of qualitative research*. Thousands Oaks, CA: Sage.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199. doi: 10.3102/0013189x08331140

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81-112. doi: 10.3102/01623737024002081

Diener, E., & Crandall, R. (1978). *Ethics in social and behavioural research*. Chicago, IL: The University of Chicago Press.

Doerr, H., & Britton, T. (2010). The STEM Teachers in professional learning communities: A knowledge synthesis. http://www.wested.org/online_pubs/resource1097.pdf

du Plessis, J., & Muzaffar, I. (2010). *Professional learning communities in the teachers' college: A resource for teacher educators*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=B16853F82C8497F8276E12AC581FCFE5?doi=10.1.1.176.4068&rep=rep1&type=pdf

DuFour, R. (2004). What is a professional learning community? *Educational leadership, 61*(8), 6-11.

DuFour, R., & DuFour, R. (2006). The power of professional learning communities. *National Forum of Educational Administration and Supervision Journal, 24*(1), 2-5.

Duncombe, R., & Armour, K. M. (2004). Collaborative professional learning: From theory to practice. *Journal of In-Service Education, 30*(1), 141-166. doi: 10.1080/13674580400200230

Durning, S. J., & Artino, A. R. (2011). Situativity theory: A perspective on how participants and the environment can interact. *Medical Teacher, 33*(3), 188-199. doi: doi:10.3109/0142159X.2011.550965

Eber, P. A., & Parker, T. S. (2007). Assessing student learning: Applying Bloom's taxonomy. *Human Service Education*, *27*(1), 45-53.

Editor. (2010, 14th February). Vodafaster and the future of our nation, *The guardian*. Retrieved from http://www.ippmedia.com/frontend/?l=13500

Education Commission of the United States. (2003). *Eight questions on teacher preparation: What does the research say? A summary of the findings*. Retrieved from http://www.ecs.org/html/educationissues/teachingquality/tpreport/home/summary.pdf

Education International. (2009). *Education for all by 2015: Education international's response to the global monitoring report 2009*. Retrieved from http://download.ei-ie.org/docs/IRISDocuments/Education/Education%20For%20All/Global%20Monitoring%20Report%202009/2009-00090-01-E.pdf

Education International. (2011). *Education for all by 2015: Education international's response to the global monitoring report 2011*. Retrieved from http://download.ei-ie.org/Docs/WebDepot/EI_GMR2011_Analysis_EN.pdf=

Englehart, J. M. (2009). Teacher–student interaction. In L. J. Saha & A. G. Dworkin (Eds.), *International handbook of research on teachers and teaching* (pp. 711-937). New York, NY: Springer.

Etkina, E. (2010). Pedagogical content knowledge and preparation of high school physics teachers. *Physical Review Special Topics - Physics Education Research, 6*(2), 020110-020136. doi: 10.1103/PhysRevSTPER.6.020110

Even, R. (1993). Subject-matter knowledge and pedagogical content knowledge: Prospective secondary teachers and the function concept. *Journal for Research in Mathematics Education, 24*(2), 94-116. doi: 10.2307/749215

Even, R., & Leslau, O. (2010). *Who will teach in a teacher shortage? Analysis of three strategies for coping with a shortage of teachers*. Retrieved from http://education.academy.ac.il/Admin/Data/Publications/teacher-shortage-eng.pdf

Ezzy, D. (2002). *Qualitative analysis: Practice and innovation*. Crows Nest, Australia: Allen & Unwin.

Fabry, D. L. (2010). Combining research-based effective teacher characteristics with effective instructional strategies to influence pedagogy. *Journal of Research in Innovative Teaching, 3*(1), 24-32.

Fantini, M. D. (1980). The right to quality education. *Educational Leadership*, 324-328. Retrieved from http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_198001_fantini.pdf

Farmer, T., Robinson, K., Elliott, S. J., & Eyles, J. (2006). Developing and implementing a triangulation protocol for qualitative health research. *Qualitative Health Research, 16*(3), 377-394. doi: 10.1177/1049732305285708

Feger, S., & Arruda, E. (2008). *Professional learning communities: Key themes from the literature.* Retrieved from fhttp://www.alliance.brown.edu/pubs/pd/PBS_PLC_Lit_Review.pdf

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013-1055.

Feistritzer, C. E. (2002). *Alternative routes to teaching*. Retrieved from http://www.ncei.com/Testimony010521.htm

Fenstermacher, G. D. (1990). The place of alternative certification in the education of teachers. *Peabody Journal of Education, 67*(3), 155-185.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 80-92.

Ferguson, P., & Womack, S. T. (1993). The impact of subject matter and on teaching performance. *Journal of Teacher Education, 44*(1), 55-63. doi: 10.1177/0022487193044001008

Ferrier-Kerr, J. L., Keown, P. A., & Hume, A. C. (2008). The role of professional development and learning in the early adoption of the New Zealand curriculum by schools. *Waikato Journal of Education, 14*, 123-138.

Fetler, M. (1999). High school staff characteristics and mathematics test results. *Education Policy Analysis Archives, 7*(9), 1-23.

Firestone, W. A. (1987). Meaning in method: The rhetoric of quantitative and qualitative research. *Educational Researcher, 16*(7), 16-21. doi: 10.3102/0013189X016007016

Flick, U. (2008). *Designing qualitative research*. London, England: Sage.

Foote, M. Q., Brantlinger, A., Haydar, H. N., Smith, B., & Gonzalez, L. (2011). Are we supporting teacher success: Insights from an alternative route mathematics teacher certification program for urban public schools. *Education and Urban Society, 43*(3), 396-425. doi: 10.1177/0013124510380420

Fraser, D. (2005). *Professional learning in effective schools: The seven principles of highly effective professional learning*. Retrieved from http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/teacher/Proflearningineffectiveschools.pdf

Fraser, J. W. (2001). *Time to cut the link between teacher preparation and certification?* Retrieved from http://www.edweek.org/ew/articles/2001/01/31/20fraser.h20.html

Frechtling, J. A., Sharp, L., Carey, N., & Vaden-Kiernan, N. (1995). *Teacher enhancement programs: A perspective on the last four decades*. Retrieved from http://www.eric.ed.gov/PDFS/ED407246.pdf

Frey, B. B., Petersen, S., Edwards, L. M., Pedrotti, J. T., & Peyton, V. (2005). Item-writing rules: Collective wisdom. *Teaching and Teacher Education, 21*(4), 357-364. doi: 10.1016/j.tate.2005.01.008

Friedrichsen, P. M., & Dana, T. M. (2005). Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching, 42*(2), 218-244. doi: 10.1002/tea.20046

Frost, N., Nolas, S. M., Brooks-Gordon, B., Esin, C., Holt, A., Mehdizadeh, L., & Shinebourne, P. (2010). Pluralism in qualitative research: The impact of different researchers and qualitative approaches on the analysis of qualitative data. *Qualitative Research, 10*(4), 441-460. doi: 10.1177/1468794110366802

Fyfe, A. (2007). *The use of contract teachers in developing countries: Trends and impact*. Retrieved from http://193.134.194.11/public/english/dialogue/sector/papers/education/wp252.pdf

Gall, M. D. (1970). The use of questions in teaching. *Review of Educational Research, 40*(5), 707-721. doi: 10.3102/00346543040005707

Gardner, A. L., & New-Gesssome, J. (2011). *A PCK rubric to measure teachers' knowledge of"inquiry-based instruction using three data sources*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Orlando, FL Retrieved from http://www.bscs.org/sites/default/files/_legacy/pdf/Community_Sessions_NARST2011_PCK%20Rubric%20Paper.pdf

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945. doi: 10.3102/00028312038004915

Geddis, A. N. (1993). Transforming subject-matter knowledge: the role of pedagogical content knowledge in learning to reflect on teaching. *International Journal of Science Education, 15*(6), 673-683. doi: 10.1080/0950069930150605

Geddis, A. N., Onslow, B., Beynon, C., & Oesch, J. (1993). Transforming content knowledge: Learning to teach about isotopes. *Science Education, 77*(6), 575-591. doi: 10.1002/sce.3730770603

Geeves, R., & Bredenberg, K. (2005). *Contract teachers in Cambodia*. Retrieved from http://ddp-ext.worldbank.org/EdStats/KHMstu05.pdf

Gess-Newsome, J. (2002). Pedagogical content knowledge: An introduction and orientation. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge* (Vol. 6, pp. 3-17). Dordrecht, The Netherlands: Springer.

Gess-Newsome, J., Cardenas, S., & Austin, B. A. (2011). *Impact of educative materials and transformative professional development on teachers pck practice and student achievement*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Orlando, FL. Retieved from http://www.bscs.org/sites/default/files/_legacy/pdf/Community_Sessions_NARST2011_Impact%20of%20Educative%20Materials.pdf

Ghefaili, A. (2003). Cognitive apprenticeship, technology, and the contextualization of learning environments. *Journal of Educational Computing, Design and Online learning, 4*, 1-27. Retrieved from http://coe.ksu.edu/users/JECDOL/Vol_4/Articles/pdfs/Aziz.pdf

Glazerman, S., Mayer, D., & Decker, P. (2006). Alternative routes to teaching: The impacts of teach for America on student achievement and other outcomes. *Journal of Policy Analysis and Management, 25*(1), 75-96. doi: 10.1002/pam.20157

Goe, L., Bell, C., & Little, O. (2008). *Approaches to evaluating teacher effectiveness: A research synthesis*. Retrieved from http://www.tqsource.org/publications/EvaluatingTeachEffectiveness.pdf

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report, 8*(4), 597-606.

Goldhaber, D. D. (2002). *The mystery of good teaching*. Retrieved from https://www.stcloudstate.edu/tpi/initiative/documents/preparation/The%20Mystery%20of%20Good%20Teaching.pdf

Goldhaber, D. D., & Brewer, D. J. (1997). Why don't schools and teachers seem to matter? Assessing the impact of unobservables on educational productivity. *The Journal of Human Resources, 32*(3), 505-523.

Goldhaber, D. D., & Brewer, D. J. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis, 22*(2), 129-145. doi: 10.3102/01623737022002129

Goodnough, K. C., & Hung, W. (2008). Engaging teachers' pedagogical content knoweldge: Adopting a nine-step problem-based learning. *Interdisciplinary Journal of Problem-Based Learning, 2*(2), 61-90.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today, 24*(2), 105-112. doi: 10.1016/j.nedt.2003.10.001

Gray, D. E. (2009). *Doing research in the real world* (2nd ed.). London, England: Sage.

Grbich, C. (2007). *Qualitative data analysis: An introduction*. London, England: Sage.

Greeno, J. G. (1989). A perspective on thinking. *American Psychologist, 44*(2), 134-141. doi: 10.1037/0003-066X.44.2.134

Greeno, J. G. (1997). On claims that answer the wrong questions. *Educational Researcher, 26*(1), 5-17. doi: 10.3102/0013189X026001005

Gronlund, N. E. (1985). *Measurement and evaluation in teaching* (5th ed.). New York, NY: Macmillan.

Gronlund, N. E., & Linn, R. L. (1990). *Measurement and evaluation in teaching* (6th ed.). New York, NY: Macmillan.

Grossman, P. L., Schoenfeld, A., & Lee, C. (2005). Teaching subject matter. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world* (pp. 201-231). San Francisco, CA: Jossey-Bass.

Grubbs, S. T. (2009). An evaluation of an alternative teacher certification program a matter of trust. *American Journal of Evaluation, 30*(4), 581-586. doi: 10.1177/1098214009349449

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal, 29*(2), 75-91. doi: 10.1007/bf02766777

Guba, E. G. (1990). *The paradigm dialog*. Newbury Park, CA: Sage.

Guba, E. G., & Lincoln, Y. S. (1982, March). *Establishing dependability and confirmability in naturalistic inquiry through an Audit*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY. Retrieved from http://www.eric.ed.gov/PDFS/ED216019.pdf

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousands Oaks, CA: Sage.

Guest, G., & McLellan, E. (2003). Distinguishing the trees from the forest: Applying cluster analysis to thematic qualitative data. *Field Methods, 15*(2), 186-201. doi: 10.1177/1525822x03015002005

Guest, G., MacQueen, K. M., & Namey, E. E. (2010). *Applied thematic analysis*. Thousand Oaks, CA: Sage.

Gurney, P. (2007). Five factors for effective teaching. *New Zealand Journal of Teachers' Work, 4*(2), 89-98.

Guskey, T. R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Crown Press.

Guskey, T. R. (2002). Professional development and teacher change: Teacher and teaching. *Theory and Practice, 8*(3), 381-391. doi: 10.1080/135406002100000512

Guskey, T. R. (2003, April). *The characteristics of effective professional development: A synthesis of lists*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, Illinois. Retrieved from http://www.eric.ed.gov/PDFS/ED478380.pdf

Guskey, T. R., & Yoon, K. S. (2009). What works in professional development? *Phi Delta Kappan, 90*(7), 495-500. doi: 10.2307/20446159

Haberman, M. (2004a). *Alternative certification: Intended and unintended consequence*. Retrieved from http://www.habermanfoundation.org/Articles/Default.aspx?id=12

Haberman, M. (2004b). Can star teachers create learning communities? *Schools as Learning Communities, 61*(8), 52-56. Retrieved from http://twinspruceplc.pbworks.com/f/Can+Star+Teachers+Create+Learning+Communities.pdf

Halldórsson, Á., & Aastrup, J. (2003). Quality criteria for qualitative inquiries in logistics. *European Journal of Operational Research, 144*(2), 321-332. doi: 10.1016/S0377-2217(02)00397-1

Harden, R. M., & Crosby, J. R. (2000). AMEE education guide No 20: The good teacher is more than a lecturer - the twelve roles of the teacher. *Medical Teacher*, *22*(4), 334-347.

Harkema, S. J. M., & Schout, H. (2008). Incorporating student-centred learning in innovation and entrepreneurship education. *European Journal of Education, 43*(4), 513-526. doi: 10.1111/j.1465-3435.2008.00372.x

Hartel, R. W., & Foegeding, E. A. (2004). Learning: Objectives, competencies, or outcomes? *Journal of Food Science Education, 3*(4), 69-70. doi: 10.1111/j.1541-4329.2004.tb00047.x

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education*, *3*(2), 109-120. doi: 10.1016/0742-051x(87)90012-6

Hattie, J. (2003). *Teachers make a difference: What is the research evidence?* Retrieved from http://www.annedavies.com/pdf/19c_expertteachers_hattie.pdf

Haycock, K. (1998). Good teaching matters: How well-qualified teachers can close the gap. *The Education Trust*, *3* (2). Retrieved from http://www.pearsonassessments.com/hai/images/NES_Publications/1999_04Haycok_397_1.pdf

Hedberg, H. E. (2008). *Technology integration professional development for teachers: Strategies for action.* (Master's thesis, Regis University). Retrieved from http://adr.coalliance.org/codr/fez/eserv/codr:256/HHedberg2008.pdf

Heine, H. (2006). *Teacher certification systems*. Retrieved from http://www.prel.org/media/140135/98_certification_systems.pdf

Henning, E. (2000). Walking with "barefoot" teachers: An ethnographically fashioned casebook. *Teaching and Teacher Education, 16*(1), 3-20. doi: 10.1016/S0742-051X(99)00042-6

Hennissen, P., Crasborn, F., Brouwer, N., Korthagen, F., & Bergen, T. (2011). Clarifying pre-service teacher perceptions of mentor teachers' developing use of mentoring skills. *Teaching and Teacher Education, 27*(6), 1049-1058. doi: 10.1016/j.tate.2011.03.009

Henze, I., Van Driel, J. H., & Verloop, N. (2009). Experienced science teachers' learning in the context of educational innovation. *Journal of Teacher Education, 60*(2), 184-199. doi: 10.1177/0022487108329275

Hien, T. (2009). *Towards an effective teachers professional development in DFLSP – CFL – VNU*. Retrieved from http://cnx.org/content/m28730/1.1/

Higgins, J., & Parsons, R. (2009). A successful professional development model in mathematics. *Journal of Teacher Education, 60*(3), 231-242. doi: 10.1177/0022487109336894

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research, 42*(2), 371-406. doi: 10.3102/00028312042002371

Ho, A., Watkins, D., & Kelly, M. (2001). The conceptual change approach to improving teaching and learning: An evaluation of a Hong Kong staff development programme. *Higher Education Research and Development, 42*, 143–169.

Hobson, A. J., Ashby, P., Malderez, A., & Tomlinson, P. D. (2009). Mentoring beginning teachers: What we know and what we don't. *Teaching and Teacher Education*, *25*(1), 207-216. doi: 10.1016/j.tate.2008.09.001

Holloway, I. (1997). *Basic concepts for qualitative research* (3rd ed.). London, England: Blackwell.

Holloway, I., & Wheeler, S. (2002). *Qualitative research in nursing* (2nd ed.). Malden, MA: Blackwell.

Holmes Group. (1990). *Tomorrow's schools: Principles for the design of professional development schools*. East Lansing, MI: Author.

Hord, S. M. (1997). *Professional learning communities: Communities of continuous inquiry and improvement*. Retrieved from http://www.sedl.org/pubs/change34/

Horn, R. A. (2002). *Understanding educational research reform: A reference handbook*. Santa Barbara, CA: Abc-Clio.

Houston, D., & Beech, M. (2002). *Designing lessons for the diverse classroom: A handbook for teachers*. Miami, FL: Florida Department of Education.

Howey, K. R., & Grossman, P. L. (1989). A study in contrast: Sources of pedagogical content knowledge for secondary english. *Journal of Teacher Education, 40*(5), 24-31. doi: 10.1177/002248718904000504

Howie, S. (2002). English language proficiency and its effects on mathematics achievements in secondary schools in South Africa. In K. M. O-saki, K. Hosea & W. Ottevanger (Eds.), *Reforming science and mathematics education in Sub-Saharan Africa* (pp. 27-38). Dar es Salaam, Tanzania: TEAMS project.

Hume, A. (2006). *Carrying out a practical investigation: The student–experienced curriculum.* (Unpublished doctoral dissertation), The University of Waikato, Hamilton, New Zealand.

Hume, A. (2010). Investigating content representations (CoRes) as pedagogical tools for science teacher education. *TDU Talk, 5*, 28-40.

Hume, A., & Berry, A. (2011). Constructing CoRes—a strategy for building PCK in pre-service science teacher education. *Research in Science Education, 41*(3), 341-355. doi: 10.1007/s11165-010-9168-3

Hume, A., & Berry, A. (2013). Enhancing the practicum experience for pre-service chemistry teachers through collaborative CoRe design with mentor teachers. *Research in Science Education*, 1-30. doi: 10.1007/s11165-012-9346-6

Humphrey, D. C., & Wechsler, M. E. (2007). Insights into alternative certification: Initial findings from a national study. *Teachers College Record, 109*(3), 483-530.

Humphrey, D. C., Wechsler, M. E., & Hough, H. J. (2008). Characteristics of effective alternative teacher certification programs. *Teachers College Record, 110*(4), 1-63.

Hunde, A. B., & Tegegne, K. M. (2010). Qualitative exploration on the application of student-centred learning in mathematics and natural sciences: The case of selected general secondary schools in Jimma, Ethiopia. *Ethiopia Journal of Education and Science, 6*(1), 41-58.

Husbands, J. (2008). Alternative routes to teacher certification. *Journal of Adult Learning in Schools, 1*(1). Retrieved from http://www.hightechhigh.org/unboxed/issue1/Unboxed_issue1.pdf

Hydén, L. C., & Bülow, P. H. (2003). Who's talking: Drawing conclusions from focus groups—some methodological considerations. *International Journal of Social Research Methodology, 6*(4), 305-321. doi: 10.1080/13645570210124865

Ibrahim, A. S. (2012a). Induction and mentoring of novice teachers: A scheme for the United Arab Emirates. *Teacher Development*, *16*(2), 235-253. doi: 10.1080/13664530.2012.688676

Ibrahim, A. S. (2012b). The learning needs of beginning teachers in the United Arab Emirates. *Journal of Education for Teaching*, *38*(5), 539-549. doi: 10.1080/02607476.2013.739791

Ingersoll, R. M. (1999). The problem of underqualified teachers in American secondary schools. *Educational Researcher, 28*(2), 26-37. doi: 10.3102/0013189x028002026

Ingersoll, R. M. (2002). The teacher shortage: A case of wrong diagnosis and wrong prescription. *NASSP Bulletin*, *86*(631), 16-31. doi: 10.1177/019263650208663103

Jacobson, N., Gewurtz, R., & Haydon, E. (2007). Ethical review of interpretive research: Problems and solutions. *Ethics and Human Research*, *29*(5), 1-8.

Jenlink, P. M. (2004). Education, social creativity, and the evolution of society. *World Futures, 60*(3), 225-240. doi: 10.1080/02604020490441211

Jessop, T., & Penny, A. (1998). A study of teacher voice and vision in the narratives of rural South African and Gambian primary school teachers. *International Journal of Educational Development, 18*(5), 393-403. doi: 10.1016/s0738-0593(98)00039-x

John, P. D. (2006). Lesson planning and the student teacher: Re-thinking the dominant model. *Journal of Curriculum Studies, 38*(4), 483-498. doi: 10.1080/00220270500363620

Johnson, B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26. doi: 10.3102/0013189x033007014

Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4-29. doi: 10.1177/0042085909352073

Johnson, C. C., Kahle, J. B., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching, 44*(6), 775-786. doi: 10.1002/tea.20149

Jones, J. (1998). Lesson planning: Towards purposeful learning and effective teaching. *Encuentro Journal, 10*, 89-98.

Kangai, C., & Bukaliya, R. (2011). Teacher development through open and distance learning: The case for Zimbabwe. *International Journal on New Trends in Education and Their Implications, 2*(4), 124-141.

Kaplan, L. S., & Owings, W. A. (2002). The politics of teacher quality: Implications for principals. *NASSP Bulletin, 86*(633), 22-41. doi: 10.1177/019263650208663303

Kaplan, R. B., & Maxwell, J. A. (2005). Qualitative research methods for evaluating computer information systems. In J. G. Anderson, C. E. Aydin & S. J. Jay (Eds.), *Evaluating health care information systems: Methods and applications* (2nd ed., pp. 30-55). Thousand Oaks, CA: Sage.

Käpylä, M., Heikkinen, J. P., & Asunta, T. (2009). Influence of content knowledge on pedagogical content knowledge: The case of teaching photosynthesis and plant growth. *International Journal of Science Education, 31*(10), 1395-1415. doi: 10.1080/09500690802082168

Kardos, S. M., & Johnson, S. M. (2007). On their own and presumed expert: New teachers' experience with their colleagues. *Teachers College Record*, *109*(9), 2083-2106.

Kardos, S. M., & Johnson, S. M. (2010). New teachers’ experiences of mentoring: The good, the bad, and the inequity. *Journal Education Change, 11*(1), 23-44. doi: 10.1007/s10833-008-9096-4

Kawulich, B. B. (2005). Participant observation as a data collection method. *Forum Qualitative Social Research*, *6*(2). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/466/997

Kee, A. N. (2011). Feelings of preparedness among alternatively certified teachers: What is the role of program features? *Journal of Teacher Education, 63*(1), 23-38. doi: 10.1177/0022487111421933

Kember, D., & Gow, L. (1992). Action research as a form of staff development in higher education. *Higher Education, 23*(3), 297-310.

Kember, D., & Gow, L. (1994). Orientations to teaching and their effect on the quality of student learning. *The Journal of Higher Education, 65*(1), 58-74. doi: 10.2307/2943877

Kilemile, J. S. (2012, August 9). Re: Changing from English to Kiswahili as medium of instruction could it bring the change in quality of education? [Udasa forum]. Retrieved from https://webmail.udsm.ac.tz/src/webmail.php

Kim, S. (2003). Research paradigms in organizational learning and performance: Competing modes of inquiry. *Information Technology, Learning, and Performance, 21*(1), 9-18.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education, 45*(2), 169-204. doi: 10.1080/03057260903142285

Kitta, S. (2004). *Enhancing mathematics teachers' pedagogical content knowledge and skills in Tanzania.* (Doctoral dissertation), University of Twente, Enschede, The Netherland.

Kitta, S., & Tilya, F. (2010). The status of learner-centred learning and assessment in Tanzania in the context of competence based curriculum. *Papers in Education and Development*, *29*, 77-91.

Kitzinger, J. (1995). Qualitative research: Introducing focus groups. *British Medical Journal*, *311*(7000), 299-302.

Koch, T. (2006). Establishing rigour in qualitative research: The decision trail. *Journal of Advanced Nursing*, *53*(1), 91-100. doi: 10.1111/j.1365-2648.2006.03681.x

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education,* *9*(1), 60-70.

Komba, W. L., & Nkumbi, E. (2008). Teacher professional development in Tanzania: Perceptions and practices. *Journal of International Cooperation in Education,* *11*(3), 67-83.

Kothari, R. C. (2009). *Research methodology: Methods and techniques* (2nd ed.). New Delhi, India: New Age International.

Krauss, S., Neubrand, M., Blum, W., & Baumert, J. (2008). The Professional Knowledge of German Secondary Mathematics Teachers: Investigations in the Context of the COACTIV Project. http://www.unige.ch/math/EnsMath/Rome2008/WG2/Papers/BLUMKR.pdf

Kriek, J., & Grayson, D. (2009). A holistic professional development model for South African physical science teachers. *South African Journal of Education*, *29*(2), 185-203.

Kruse, S., Louis, K. S., & Bryk, A. (1994). *Building professional community in schools*. Retrieved from http://www.wcer.wisc.edu/archive/cors/issues_in_restructuring_schools/issues_no_6_spring_1994.pdf

Kudzai, C., Moses, K., & Emily, G. (2011). Quality or mere formality? Food for thought in the use of teacher-made tests in Masvingo rural secondary schools in Zimbabwe. *Journal of Emerging Trends in Educational Research and Policy, 2*(6), 418-425.

Kuhn, T. S. (1970). *The structure of scientific revolution* (2 ed. Vol. 2). Chicago, IL: The University of Chicago Press.

Kuijpers, J. M., Houtveen, A. A. M., & Wubbels, T. (2010). An integrated professional development model for effective teaching. *Teaching and Teacher Education, 26*(8), 1687-1694. doi: 10.1016/j.tate.2010.06.021

Kunje, D., & Stuart, J. (1999). Supporting untrained teachers in Malawi. *International Journal of Educational Development, 19*(2), 157-166. doi: 10.1016/S0738-0593(98)00006-6

Kupermintz, H. (2003). Teacher effects and teacher effectiveness: A validity investigation of the Tennessee value added assessment system. *Educational Evaluation and Policy Analysis, 25*(3), 287-298. doi: 10.3102/01623737025003287

Kvale, S., & Brinkmann, S. (2008). *Interviews: Learning the craft of qualitative research interviewing*. Thousand Oaks, CA: Sage.

Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education, 19*(2), 149-170. doi: 10.1016/s0742-051x(02)00101-4

Lalitha, H. D. A. (2005). *Development of a model for the continuing professional development of teachers: A qualitative investigation.* (Doctoral dissertation), University of Wollongong, Wollongong, Australia. Retrieved from http://trove.nla.gov.au/work/153082564?versionId=166834848

Lambert, H., & McKevitt, C. (2002). Anthropology in health research: From qualitative methods to multidisciplinarity. *British Medical Journal, 325*(7357), 210-213. doi: 10.1136/bmj.325.7357.210

Lambson, D. (2010). Novice teachers learning through participation in a teacher study group. *Teaching and Teacher Education, 26*(8), 1660-1668. doi: 10.1016/j.tate.2010.06.017

Lara-Alecio, R., Tong, F., Irby, B. J., Guerrero, C., Huerta, M., & Fan, Y. (2012). The effect of an instructional intervention on middle school english learners' science and english reading achievement. *Journal of Research in Science Teaching, 49*(8), 987-1011. doi: 10.1002/tea.21031

Lave, J., & Wenger, E. (1991). *Situative learning: Legitimate peripheral participation.* New York, NY: Cambrige University Press.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575-614. doi: 10.3102/0034654307309921

Lawson, E. (2001). Information and rational meanings of deception: Implication for deceptions methods in research. *Ethics and Behaviour, 11*(2), 115-130.

Lea, S. J., Stephenson, D., & Troy, J. (2003). Higher education students' attitudes to student-centred learning: Beyond 'educational bulimia'? *Studies in Higher Education, 28*(3), 321-334. doi: 10.1080/03075070309293

LeCompte, M. D., & Schensul, J. J. (1999). *Designing and conducting ethnographic research*. London, England: AltaMira Press.

LeCompte, M. D., & Schensul, J. J. (2010). *Designing and conducting ethnographic research: An introduction* (2nd ed. Vol. 1). Blue Ridge Summit, PA: Rowman & Littlefield.

Lederman, N., & Gess-Newsome, J. (1992). Do subject matter knowledge, pedagogical knowledge, and pedagogical content knowledge constitute the ideal gas law of science teaching? *Journal of Science Teacher Education, 3*(1), 16-20. doi: 10.1007/bf02614732

Lee, E., Brown, M. N., Luft, J. A., & Roehrig, G. H. (2007). Assessing beginning secondary science teachers' pck: Pilot year results. *School Science and Mathematics, 107*(2), 52-60. doi: 10.1111/j.1949-8594.2007.tb17768.x

Lee, R. M. (2000). *Unobtrusive methods in social research*. Buckingham, PA: Open University Press.

Lee, Y.-C. (2011). Enhancing pedagogical content knowledge in a collaborative school-based professional development program for inquiry-based science teaching. *Asia-Pacific Forum on Science Learning and Teaching*, *12*(1), 1-29. http://www.ied.edu.hk/apfslt/download/v12_issue2_files/leeyc.pdf

Legère, K. (2010). Swahili vs. English in Tanzania and the political discourse. *Languages and Cultures, 44*, 47-66. Retrieved from http://www.orient.uw.edu.pl/web-kjika/images/stories/SDALC44/legere.pdf

Legler, R. (2002). *The impact of alternative certification in the Midwest*. Retrieved from http://www.eric.ed.gov/PDFS/ED475775.pdf

Lennartsson, B. (1997). *Why there are different teaching preferences in different disciplines*. Retrieved from http://www.ida.liu.se/~bln/F-Docs/RUC-97.html

Leslie, H. (2001). *Teacher mentoring as professional development*. Retrieved from http://www.ericdigests.org/2002-3/mentoring.htm

Levin, H., Belfield, C., Muennig, P., & Rouse, C. (2004). *The costs and benefits of an excellent education for all of America's children*. Retrieved from http://www.cbcse.org/media/download_gallery/Leeds_Report_Final_Jan2007.pdf

Levin, M., & Greenwood, D. (2011). Revitalizing university by reinventing the social sciences. In N. K. Denzin & Y. S. Lincolin (Eds.), *The sage handbook of qualitative reseach* (4th ed., pp. 27-42). London, England: Sage.

Levine, T. H., & Marcus, A. S. (2010). How the structure and focus of teachers' collaborative activities facilitate and constrain teacher learning. *Teaching and Teacher Education, 26*(3), 389-398. doi: 10.1016/j.tate.2009.03.001

Leyendecker, R., Ottevanger, W., & van den Akker, J. H. (2008). *Curricula, examinations, and assessment in secondary education in Sub-Saharan Africa: Secondary education in Africa (SEIA)*. Washington, DC: World Bank.

Li, D. (2004). Trustworthiness of think-aloud protocols in the study of translation processes. *International Journal of Applied Linguistics, 14*(3), 301-313. doi: 10.1111/j.1473-4192.2004.00067.x

Lieberman, A. (1995). Practices that support teacher development: Transforming conceptions of professional learning. In F. Stevens (Ed.), *Innovating and evaluating science education: NSF evaluation forums*, 1992-94 (pp. 67-78). Retrieved from http://www.nsf.gov/pubs/1995/nsf95162/nsf_ef.pdf.

Lieberman, A. (2000). Networks as learning communities: Shaping the future of teacher development. *Journal of Teacher Education, 51*(3), 221-227. doi: 10.1177/0022487100051003010

Lihaya, H. S. (2009). *The perceived influence of pre-service–short term trained teachers on students' interest in science subjects: A case study of selected community secondary schools in Mufindi district Iringa region.* (Unpublished master's thesis), University of Dar es Salaam, Dar es Salaam,Tanzania.

Limbach, B., & Waugh, W. (2010). Developing higher level thinking. *Journal of Instructional Pedagogies, 3,* 1-9. Retrieved from http://www.aabri.com/manuscripts/09423.pdf

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

Little, J. W. (2002). Locating learning in teachers' communities of practice: Opening up problems of analysis in records of everyday work. *Teaching and Teacher Education, 18*(8), 917-946. doi: 10.1016/S0742-051X(02)00052-5

Liu, R., Qiao, X., & Liu, Y. (2006). A paradigm shift of learner-centered teaching style: Reality or illusion? *Arizona Working Papers in SLAT, 13,* 77-92. Retrieved from http://www.coh.arizona.edu/AWP/AWP13/AWP13%5BLiu%5D.pdf

Livesey, C. (2006). *Relationship between positivism, interpretivism and sociological research*. Retrieved from http://www.sociology.org.uk/revgrm5.pdf

Lodico, M. G., Spaulding, D. T., & Voegtle, K. H. (2006). *Methods in educational research: From theory to practice*. San Francisco, CA: Jossey-Bass.

Lonsdale, M., & Ingvarson, L. (2003). *Initiatives to address teacher shortage*. Retrieved from http://research.acer.edu.au/workforce/4

Loucks-Horsley, S. (1995). Professional development and the learner-centred school. *Theory into Practice, 34*(4), 265-271.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*(5), 258-271. doi: 10.1111/j.1949-8594.1999.tb17484.x

Loucks-Horsley, S., Harding, C. K., Arbuckle, M. A., Murray, L. B., Dubea, C., & Williams, M. K. (1987). *Continuing to learn: A guidebook for teacher development*. Andover, MA: Regional Laboratory for Educational Improvement of the Northeast and Islands, and the National Staff Development Council.

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics* (3rd ed.). Thousand Oaks, CA: Corwin Press.

Loucks-Horsley, S., Stiles, K., & Hewson, P. (1996). Principles of effective professional development for mathematics and science education: A synthesis of standards. *NISE Brief, 1*(1), 1-6. Retrieved from http://archive.wceruw.org/nise/Publications/Briefs/NISE_Brief_Vol_1_No_1.pdf

Loughran, J. (2010). *What expert teachers do: Enhancing professional knoweldege for classroom practice*. Crows Nest, Austalia: Allen & Unwin.

Loughran, J., & Berry, A. (2010, February). *What do we know about effective CPD for developing science teachers' pedagogical content knowledge?* Paper presented at the International Seminar and Professional Reflections, National Science Learning Centre, York, England. Retrieved from https://www.sciencelearningcentres.org.uk/research-and-impact/research-seminars/NSLC%20UYSEG%20seminar%20Berry.pdf

Loughran, J., Berry, A., & Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. Clayton, Australia: Sense.

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*(4), 370-391 doi: 10.1002/tea.20007

Louis, K. S., Marks, H. M., & Kruse, S. (1996). Teachers' professional community in restructuring schools. *American Educational Research Journal, 33*(4), 757-798. doi: 10.3102/00028312033004757

Lujara, S. K., Kissaka, M. M., Trojer, L., & Mvungi, N. H. (2006). Introduction of open-source e-learning environment and resources: A novel approach for secondary schools in Tanzania. *International Journal of Human and Social Sciences, 1*(4), 239-243.

Lynd, M. (2005). *Fast-track teacher training: Models for consideration for Southern Sudan*. Retrieved from http://people.umass.edu/educ870/teacher_education/Documents/Lynd%20-%20Fast-track%20Southern%20Sudan.pdf

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research, 16*(2), 193-205. Retrieved from http://www.iier.org.au/iier16/mackenzie.html

Macnee, L. C., & McCabe, S. (2008). *Understanding nursing research: Using research evidence-based practice*. Philadelphia, PA: Lippincott Williams & Wilkins.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lenderman (Eds.), *Examining pedagogical content knowledge* (pp. 95-132). Dordrecht, The Netherlands: Kluwer Academic.

Marks, R. (1990). Pedagogical content knowledge: From a mathematical case to a modified conception. *Journal of Teacher Education, 41*(3), 3-11. doi: 10.1177/002248719004100302

Marso, R. N., & Pigge, F. L. (1991). An analysis of teacher-made tests: Item types, cognitive demands, and item construction errors. *Contemporary Educational Psychology, 16*(3), 279-286. doi: 10.1016/0361-476X(91)90027-I

Maxwell, J. A. (2008). *Designing a qualitative study*. Retrieved from http://www.corwin.com/upm-data/23772_Ch7.pdf

Mayer, R. E. (2004). Should there be a three-strike rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*(1), 14-19. doi: 10.1037/0003-066X.59.1.14

McCall, M. J. (2008). *Qualities of effective secondary science teachers: Perspectives of university biology students.* (Doctoral dissertation, Baylor University). Retrieved from https://beardocs.baylor.edu/xmlui/handle/2104/5244

McCombs, B. L. (2003). A framework for the redesign of K-12 education in the context of current educational reform. *Theory into Practice, 42*(2), 93-101.

McCombs, B. L., & Whisler, J. S. (1997). *The learner-centered classroom and school: Strategies for increasing student motivation and achievement*. San Fransisco, CA: Jossey-Bass.

McEwan, E. K. (2002). *Ten traits of highly effective teachers: How to hire, coach, and mentor successful teachers*. Thousand Oaks, CA: Sage.

McEwan, E. K. (2010). *Ten traits of highly effective teachers: How to hire, coach, and mentor successfull teachers* (2nd ed.). Thousand Oaks, CA: Sage.

McKerchar, M. A. (2008). Philosophical paradigms, inquiry strategies and knowledge claims: Applying the principles of research design and conduct to taxation. *eJournal of Tax Research, 6*(1), 5-22. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1464141

McMorris, R. F., & Boothroyd, R. A. (1993). Tests that teachers build: An analysis of classroom tests in science and mathematics. *Applied Measurement in Education, 6*(4), 321-342. doi: 10.1207/s15324818ame0604_5

Meena, W. E. (2009). *Curriculum innovation in teacher education: Exploring conceptions among Tanzanian teacher educators.* (Doctoral dissertation), Abo University, Biskopspatan, Finland.

Melville, W. (2010). *Professional learning in a school-based community of science teachers*. Rotterdam, The Netherlands: Sense.

Melville, W., & Yaxley, B. (2009). Contextual opportunities for teacher professional learning: The experience of one science department. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(4), 357-368.

Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass.

Mfuru, I. C. (2010). *Investigation of short term teacher preparation programmes on the quality of teaching and learning secondary school science in Tanzania.* (Unpublished master's thesis), University of Dar es Salaam, Dar es Salaam, Tanzania.

Mhishi, M., Bhukuvhani, C. E., & Sana, A. F. (2012). Science teacher training programme in rural schools: An ODL lesson from Zimbabwe. *The International Review of Research in Open and Distance Learning, 13*(1), 72-86.

Miles, M. B. (1979). Qualitative data as an attractive nuisance: The problem of analysis. *Administrative Science Quarterly, 24*(4), 590-601.

Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. London, England: Sage.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.

Millward, M. (2006). *Teachers and educational quality: Monitoring global needs for 2015*. Retrieved from http://www.uis.unesco.org/TEMPLATE/pdf/Teachers2006/TeachersReport.pdf

Ministry of Education and Culture. (1995). *Education and training policy*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Culture. (2001). *Teacher education master plan: Medium term and strategic program framework 2000-2005*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Culture. (2004). *Deliberate support to licensed teacher trained through the induction course programme: Facilitator and mentor guide*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Culture. (2005). *Basic mathematics syllabus for secondary schools*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Vocational Training. (2007). *Chemistry syllabus for ordinary secondary education Form I-IV*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Vocational Training. (2008a). *Basic education statistics in Tanzania*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Vocational Training. (2008b). *Education sector development programme (2008-17)*. Retrieved from http://planipolis.iiep.unesco.org/upload/Tanzania%20UR/Tanzania-ESDP-2008-2017.pdf

Ministry of Education and Vocational Training. (2008c). *Secondary education curriculum for Tanzania mainland*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Vocational Training. (2010). *Secondary education development programme II (July 2010 – June 2015)*. Retrieved from http://moe.go.tz/PDF/SEDP%20II-%20FINAL%20DRAFT%20-%2023%20JUNE%202010.pdf.

Mitchell, D. E., & Romero, L. S. (2010). The politics and practice of alternative teacher certification. *Educational Administration Quarterly, 46*(3), 363-394. doi: 10.1177/0013161x10375272

Mizell, H. (2009). *Delve into NSDC's new definition of professional learning*. Retrieved from http://www.learningforward.org/docs/learning-system/system5-09.pdf?sfvrsn=2

Mkulo, M. (2010). *Tanzania budget speech for financial year 2010/2011*. Retrieved from http://www.parliament.go.tz/bunge/docs/keyeconomic2010.pdf

Mokhele, M. L. (2011). *Teachers' perspectives on continuing professional development: A case study of the Mpumalanga secondary science initiative (MSSI) project.* (Doctoral dissertation), University of South Africa, Pretoria, South Africa. Retrieved from http://uir.unisa.ac.za/bitstream/handle/10500/4871/thesis_mokhele_ml.pdf?sequence=1

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*(2), 125-145. doi: 10.1016/0272-7757(94)90003-5

Monk, D. H., & King, J. (1994). Multilevel teacher resource effects on pupil performance in secondary mathematics and science: The case of teacher subject-matter preparation. In R. Ehrenberg (Ed.), *Contemporary policy issues: Choices and consequences in education* (pp. 29-58). Ithaca, NY: ILR Press.

Morgan, D. L. (2007). Paradigms lost and pragmatism regained. *Journal of Mixed Methods Research, 1*(1), 48-76. doi: 10.1177/2345678906292462

Morrison, K. (1993). *Planning and accomplishing school-centred evaluation*. Norfolk, VA: Peter Fransis.

Mtika, P., & Gates, P. (2010). Developing learner-centred education among secondary trainee teachers in Malawi: The dilemma of appropriation and application. *International Journal of Educational Development, 30*(4), 396-404. doi: 10.1016/j.ijedudev.2009.12.004

Muijs, D., & Reynolds, D. (2011). *Effective teaching: Evidence and practice* (3rd ed.). London, England: Sage.

Muijs, D., Campbell, J., Kyriakides, L., & Robinson, W. (2005). Making the case for differentiated teacher effectiveness: An overview of research in four key areas. *School Effectiveness and School Improvement, 16*(1), 51-70. doi: 10.1080/09243450500113985

Mulkeen, A., & Chen, D. (Eds.). (2008). *Teachers for rural schools: Experiences in Lesotho, Malawi, Mozambique, Tanzania, and Uganda*. Washington, DC: World Bank.

Mwaipopo, T. J. (2010). *Provision of quality education in the context of secondary schools with one or two teacher.* (Unpublished master's thesis), University of Dar es Salaam, Dar es Salaam, Tanzania.

Nagy, C. J., & Wang, N. (2007). The alternate route teachers' transition to the classroom: Preparation, support, and retention. *NASSP Bulletin, 91*(1), 98-113. doi: 10.1177/0192636506299153

National Bureau of Stastics. (2012). *Tanzania population and housing censuses*. Retrieved from http://www.nbs.go.tz/

National Centre for Alternative Certification. (2006). *Alternative routes to teacher certification: An overview*. Retrieved from http://www.teach-now.org/overview.html

National Middle School Association. (2004). *Research summary: Professional development for teachers*. Retrieved from http://www.amle.org/portals/0/pdf/research/Research_Summaries/Professional_Development.pdf

National Research Council. (2000). Inquiry and the national science education standards: A guide for teaching and learning. http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_inquiry_table.pdf

Nelson, M. D. (1998). Professional development schools: An implementation model. *NASSP Bulletin, 82*(600), 93-102. doi: 10.1177/019263659808260015

Nezvalová, D. (2011). Researching science teacher pedagogical content knowledge. *Problems of Education in the 21st Century, 35*, 104-118.

Ng, J. C. (2003). Teacher shortages in urban schools: The role of traditional and alternative certification routes in filling the voids. *Education and Urban Society, 35*(4), 380-398. doi: 10.1177/0013124503255453

Nkhoma, P. (2002). What successful black South African students consider as factors of their success. *Educational Studies in Mathematics, 50*(1), 103-113. doi: 10.1023/a:1020509528995

Nilsson, P. (2008). Teaching for understanding: The complex nature of pedagogical content knowledge in pre-service education. International Journal of Science Education, 30(10), 1281-1299. doi: 10.1080/09500690802186993

Noor, M. K. B. (2008). Case study: A strategic research methodology. *American Journal of Applied Sciences*, *5*(11), 1602-1604.

Norman, D. A., & Spohrer, J. C. (1996). Learner-centered education. *Journal of Communications of the ACM, 39*(4), 24-27. doi: 10.1145/227210.227215

Notar, C. E., Zuelke, D. C., Wilson, J. D., & Yunker, B. D. (2004). The table of specifications: Insuring accountability in teacher made tests. *Journal of Instructional Psychology, 31*(2), 115-129.

Nuangchalerm, P. (2012). Enhancing pedagogical content knowledge in preservice science teachers. *Higher education studies, 2*(2), 66-71. doi: 10.5539/hes.v2n2p66

Nunnery, J., Kaplan, L. S., Owings, W. A., & Pribesh, S. (2010). The effects of troops to teachers on student achievement: One state's study. *NASSP Bulletin*. doi: 10.1177/0192636509359338

Nunokawa, K. M. L. (2012). *Teacher perception on coaching and effective development implementation.* (Doctoral dissetation), University of Southern California, Los Angeles, CA. Retrieved from http://digitallibrary.usc.edu/cdm/compoundobject/collection/p15799coll127/id/676377/rec/24

Nykiel-Herbert, B. (2004). Mis-constructing knowledge: The case of learner-centred pedagogy in South Africa. *Prospects, 34*(3), 249-265. doi: 10.1007/s11125-004-5306-x

O'Neill, R. (1991). The plausible myth of learner-centredness: Or the importance of doing ordinary things well. *ELT Journal, 45*(4), 293-304. doi: 10.1093/elt/45.4.293

O’Sullivan, M. (2004). The reconceptualisation of learner-centred approaches: A Namibian case study. *International Journal of Educational Development, 24*(6), 585-602. doi: 10.1016/s0738-0593(03)00018-x

Okuni, A. (2007). Decentralization and revitalizing school-base teacher support and continuous professional development at primary school level: Why it has failed in East Africa. *Journal of Comparative Education and History of Education, 13*(2), 107-123.

Omar, N., Haris, S. S., Hassan, R., Arshad, H., Rahmat, M., Zainal, N. F. A., & Zulkifli, R. (2012). Automated analysis of exam questions according to Bloom's taxonomy. *Procedia - Social and Behavioral Sciences, 59*(0), 297-303. doi: 10.1016/j.sbspro.2012.09.278

Omari, I. M. (2007, 15th december). Kiswahili and english which is which in today`s world?, *The Guardian*. Retrieved from http://ip-216-69-164-44.ip.secureserver.net/ipp/guardian/2008/02/18/108617.html

Omari, I. M., & Anney, V. N. (2008). *Education for all fast track initiative in Tanzania: A status report for the Commonwealth Secretariat.* University of Dar es salaam. Dar es Salaam, Tanzania.

Omari, I. M., Mbise, A. S., Mahenge, S. T., Malekela, G. A., & Besha, M. P. (1983). *Universal primary education in Tanzania*. Retrieved from http://idlbnc.idrc.ca/dspace/bitstream/10625/7084/1/57402.pdf

O'Neill, G., & McMahon, T. (2005). *Student-centred learning: What does it mean for students and lecturers?* Retrieved from http://www.aishe.org/readings/2005-1/oneill-mcmahon-Tues_19th_Oct_SCL.html

Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research, 81*(3), 376-407. doi: 10.3102/0034654311413609

Opie, C. (2004). Research approaches. In C. Opie & P. J. Sikes (Eds.), *Doing educational research: A guide to first-time research* (pp. 73-94). London: England: Sage.

Organisation for Economic Co-operation and Development. (2010). *PISA 2009 results: What makes a school successful?–resources, policies and practices*

(Volume IV). Retrieved from http://www.oecd.org/pisa/pisaproducts/48852721.pdf

Organisation for Economic Co-operation and Development. (2012). *Strong performers and successful reformers in education: Lessons from PISA for Japan*. Retrieved from http://www.oecd-ilibrary.org/education/lessons-from-pisa-for-japan_9789264118539-en

O-saki, K. M. (2007). Science and mathematics teacher preparations in Tanzania: Lesson from teacher improvement projects in Tanzania,1965-2005. *NUE Journal of International Education Cooperation, 2*, 51-64.

O-saki, K. M. (2008). Science education in Tanzania: The changing content and form of science teaching and teacher education. In R. K. Coll & N. Taylor (Eds.), *Science education in context: An international examination of the influence of context on science curriculum development implementation* (pp. 235-350). Rotterdam, The Netherlands: Sense.

Owen, S. (2004). *Situativity theory and emerging trends in teacher professional development*. Retrieved from http://www.aare.edu.au/04pap/owe04331.pdf

Owings, W. A., Kaplan, L. S., Nunnery, J., Marzano, R., Myran, S., & Blackburn, D. (2006). Teacher quality and troops to teachers: A national study with implications for principals. *NASSP Bulletin, 90*(2), 102-131. doi: 10.1177/0192636506289023

Panasuk, R. M., & Todd, J. (2005). Effectiveness of lesson planning: Factor analysis. *Journal of Instructional Psychology, 32*(3), 215-232.

Pandey, S. (2009). Barefoot teachers and the millennium goal EFA 2015: The dilemma of developing countries. *International Forum of Teaching and Studies, 5*(1), 52-61.

Paris, C., & Combs, B. (2006). Lived meanings: What teachers mean when they say they are learner-centered. *Teachers and Teaching, 12*(5), 571-592. doi: 10.1080/13540600600832296

Park, S., & Oliver, J. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a Conceptual tool to understand teachers as professionals. *Research in Science Education, 38*(3), 261-284. doi: 10.1007/s11165-007-9049-6

Park, S., Jang, J.-Y., Chen, Y.-C., & Jung, J. (2011). Is pedagogical content knowledge (pck) necessary for reformed science teaching?: Evidence from an empirical study. *Research in Science Education, 41*(2), 245-260. doi: 10.1007/s11165-009-9163-8

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Peca, K. (2000). *Critical educational administration: Research, theory and practice*. Retrieved from http://163.20.137.3/doctor/wp-content/uploads/2011/08/Critical-Ed-Adm-ED455564.pdf

Pella, S. (2011). A situative perspective on developing writing pedagogy in a teacher professional learning community. *Teacher Education Quarterly, 38*(1), 107-125.

Penso, S. (2002). Pedagogical content knowledge: How do student teachers identify and describe the causes of their pupils' learning difficulties? *Asia-Pacific Journal of Teacher Education, 30*(1), 25-37. doi: 10.1080/13598660120114959

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44*(4), 921-958. doi: 10.3102/0002831207308221

Peressini, D., Borko, H., Romagnano, L., Knuth, E., & Willis, C. (2004). A conceptual framework for learning to teach secondary mathematics: A situative perspective. *Educational Studies in Mathematics, 56*, 67-96.

Peterson, K. (2002). The professional development of principals: Innovations and opportunities. *Educational Administration Quarterly, 38*(2), 213-232. doi: 10.1177/0013161x02382006

Petrou, M. (2007, February). *Using mixed-methods methodology to investigate Cypriot pre-service teachers' mathematics content knowledge.* Paper presented at the European Research in Mathematics Education, Larnaca, Cyprus. Retreived from http://ermeweb.free.fr/CERME%205/WG11/11_Petrou.pdf

Phillips, J. (2003). Powerful learning: Creating learning communities in urban school reform. *Journal of Curriculum and Supervision, 18*(3), 240-258.

Piggot-Irvine, E., Aitken, H., Ritchie, J., Ferguson, P. B., & McGrath, F. (2009). Induction of newly qualified teachers in New Zealand. *Asia-Pacific Journal of Teacher Education, 37*(2), 175-198. doi: 10.1080/13598660902804030

Pillay, H. (2002). Understanding learner-centredness: Does it consider the diverse needs of individuals? *Studies in Continuing Education, 24*(1), 93-102. doi: 10.1080/01580370220130468

Pope, C., & Mays, N. (1995). Reaching the parts other methods cannot reach: An introduction to qualitative methods in health and health services research. *British Medical Journal, 311*(6996), 42-45. doi: 10.1136/bmj.311.6996.42

Popham, W. J. (2013). *Classroom assessment: What teachers need to know* (7th ed.). Los Angeles, CA: Allyn & Bacon.

Public Policy Institute of California. (2003). *New insights into school and classroom factors affecting student achievement*. Retrieved from http://www.ppic.org/content/pubs/rb/RB_803JBRB.pdf

Punch, K. F. (2005). *Introduction to social research: Quantitative and qualitative approaches* (2nd ed.). London, England: Sage.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15. doi: 10.3102/0013189x029001004

Qorro, M. (2006). *Does language of instruction affect quality of education?* Retrieved from http://hakielimu.org/files/publications/document101does_lang_instruc_fct_qual_edu_en.pdf

Randall, E. S. (2008). *Teacher development and management in the context of large under-resoursed science classess.* (Master's thesis), University of Pretoria, Pretoria. Retrieved from http://upetd.up.ac.za/thesis/available/etd-07102009-170724/unrestricted/dissertation.pdf

Rani, J. S. (2004). *Educational measurement and evaluation*. New Delhi: Discovery Publishing House.

Rasheed, S. (2000, June). *Defining quality in education*. Paper presented at the International Working Group on Education, Florence, Italy. Retrieved from http://www.unicef.org/education/files/QualityEducation.PDF

Richardson, V. (2003). The dilemmas of professional development. *Phi Delta Kappa*, *84*(5), 401-406.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica*, *73*(2), 417-458.

Robson, C. (2002). *Real world research: A resource for social research scientists and practioners* (2nd ed.). Oxford, England: Blackwell.

Rockoff, J. E. (2003). The impact of individual teachers on student achievement: Evidence from panel data. *American Economic Review, 94*(2), 247-252.

Rogan, J. M., & Grayson, D. J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25*(10), 1171-1204. doi: 10.1080/09500690210145819

Rogers, M. P., Abell, S. K., Lannin, J., Wang, C.-Y., Musikul, K., Barker, D., & Shannon, D. (2007). Effective professional development in science and mathematics education: Teachers' and facilitators' views. *International Journal of Science and Mathematics Education*, *5*(3), 507-532. doi: 10.1007/s10763-006-9053-8

Rollnick, M. (1998). The influence of language on the second language teaching and learning of science. In W. W. Cobern (Ed.), *Socio-cultural perspectives on science education* (Vol. 4, pp. 121-137). Dordrcht, The Netherlands: Kluwer Academic.

Rollnick, M. (2000). Current issues and perspectives on second language learning of science. *Studies in Science Education*, *35*(1), 93-121. doi: 10.1080/03057260008560156

Rollnick, M., & Rutherford, M. (1996). The use of mother tongue and english in the learning and expression of science concepts: A classroom-based study. *International Journal of Science Education*, *18*(1), 91-103. doi: 10.1080/0950069960180108

Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N., & Ndlovu, T. (2008). The place of subject matter knowledge in pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education, 30*(10), 1365-1387. doi: 10.1080/09500690802187025

Rosenberg, M. S., & Sindelar, P. T. (2005). The proliferation of alternative routes to certification in special education. *The Journal of Special Education, 39*(2), 117-127. doi: 10.1177/00224669050390020201

Ross, J. A., Hogaboam-Gray, A., & Bruce, C. (2006). The impact of a professional development program on student achievement in grade 6 mathematics. *Journal of Mathematics Teacher Education, 9*(6), 551-577. doi: 10.1007/s10857-006-9020-x

Rowley, J. (2002). Using case studies in research. *Management Research News, 25*(1), 16-25.

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative interviewing: The art of hearing data* (2nd ed.). Thousand Oaks, CA: Sage.

Russett, J. L. (2008). *Women's perceptions of high risk drinking: Understanding binge drinking in a gender biased setting.* (Doctoral dissertation, The College of William and Mary). Retrieved from http://books.google.co.nz/books?id=MlmVt0Fjv3gC

Salyer, B. A. (2003). Alternatively and traditionally certified teachers: The same but different. *NASSP Bulletin, 87*(636), 16-27. doi: 10.1177/019263650308763603

Santiago, P. (2002). *Teacher demand and supply: Improving teaching quality and addressing teacher shortages*. Retrieved from http://www.oecd-ilibrary.org/education/teacher-demand-and-supply_232506301033

Sarantakos, S. (2005). *Social research* (3rd ed.). New York, NY: Palgrave Macmillan.

Schensul, S. L., Schensul, J. J., & LeCompte, M. D. (1999). *Essential ethnographic methods: Observation, interviews and questionnaires*. Boston, MA: AltaMira Press.

Schmitt, E. M., Hu, A. C., & Bachrach, P. S. (2008). Course evaluation and assessment: Examples of a learner-centered approach. *Gerontology and Geriatrics Education, 29*(3), 290-300. doi: 10.1080/02701960802359524

Schneider, R. M., & Plasman, K. (2011). Science teacher learning progressions: A review of science teachers' pedagogical content knowledge development. *Review of Educational Research, 20*(10), 1-36. doi: 10.3102/0034654311423382

Schuh, K. L., & Barab, S. A. (2008). Philosophical perspectives. In J. M. Spector, M. D. Merrill, J. v. Merrienboer & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed., pp. 67-87). New York, NY: Lawrence Erlbaum Associates.

Schunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Boston, MA: Pearson.

Schutt, R. K. (2006). *Investigating the social world: The process and practice of research* (5th ed.). Thousand Oaks, CA: Pine Forge.

Schwandt, T. A. (1994). Constructivist, interpretivist approaches to human inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 118-137). Thousand Oaks, CA: Sage.

Schwartz, R. A., & Bryan, W. A. (1998). What is professional development? *New Directions for Student Services, 1998*(84), 3-13. doi: 10.1002/ss.8401

Schweisfurth, M. (2011). Learner-centred education in developing country contexts: From solution to problem? *International Journal of Educational Development, 31*(5), 425-432. doi: 10.1016/j.ijedudev.2011.03.005

Scott, D. (1996). Methods and data in educational research. In D. Scott & R. Usher (Eds.), *Understanding educational research* (pp. 52-72). London, England: Routledge.

Seale, C., Gobo, G., Gubrium, J. F., & Silverman, D. (2004). *Qualitative research practice*. London, England: Sage.

Seftor, N. S., & Mayer, D. P. (2003). *The effect of alternative certification on student achievement: A literature review*. Retrieved from http://www.mathematica-mpr.com/PDFs/effectalt.pdf

Segall, A. (2004). Revisiting pedagogical content knowledge: The pedagogy of content/the content of pedagogy. *Teaching and Teacher Education, 20*(5), 489-504. doi: 10.1016/j.tate.2004.04.006

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and social sciences* (3rd ed.). New York, NY: Teacher College Press.

Semali, L. M., & Mehta, K. (2012). Science education in Tanzania: Challenges and policy responses. *International Journal of Educational Research, 53*(0), 225-239. doi: 10.1016/j.ijer.2012.03.012

Senkoro, F. E. (2005, December). *Language of instruction: The forgotten factor in education standards in Africa*. Paper presented at the CODSRIA general Assambly, Maputo, Mozambique. Retrieved from http://www.codesria.org/IMG/pdf/senkoro.pdf

Servage, L. (2009). Who is the "professional" in a professional learning community? An exploration of teacher professionalism in collaborative professional development settings. *Canadian Journal of Education, 32*(1), 149-171.

Shaban, A. N. (2007). *Licensed teachers' professional development and the fate of teaching science and mathematics in Tanzania secondary schools.* (Unpublished master's thesis), University of Dar es Salaam, Dar es Salaam,Tanzania.

Shaw, M. (2008). The impact of alternative teacher certification programs on teacher shortages. *The International Journal of Learning, 15*(3), 90-98.

Shen, J. (1997). Has the alternative certification policy materialized its promise? A comparison between traditionally and alternatively certified teachers in public schools. *Educational Evaluation and Policy Analysis, 19*(3), 276-283. doi: 10.3102/01623737019003276

Shepard, L. A. (2000). *The role of classroom assessment in teaching and learning*. Retrieved from http://datause.cse.ucla.edu/DOCS/las_rol_2000.pdf

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researchers, 15*(2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-23.

Shymansky, J. A., Yore, L. D., & Anderson, J. O. (2004). Impact of a school district's science reform effort on the achievement and attitudes of third- and fourth-grade students. *Journal of Research in Science Teaching, 41*(8), 771-790. doi: 10.1002/tea.20025

Sikes, P. (2004). Doing educational research: A guide to first-time research. In C. Opie & P. J. Sikes (Eds.), *Methodology, procedure and the ethical concern* (pp. 15-33). London, England: Sage.

Sikoyo, L. (2010). Contextual challenges of implementing learner-centred pedagogy: The case of the problem-solving approach in Uganda. *Cambridge Journal of Education, 40*(3), 247-263. doi: 10.1080/0305764x.2010.509315

Sikwibele, A. L., & Mungoo, J. K. (2009). Distance learning and teacher education in Botswana: Opportunities and challenges. *International Review of Research in Open and Distance Learning, 10*(4), 1-16.

Slavin, R. E. (2003). A reader's guide to scientifically based research. *Educational Leadership, 60*(5), 12-16.

Sorensen, P., Young, J., & Mandzuk, D. (2005). Alternative routes into the teaching profession. *Interchange, 36*(4), 371-403. doi: 10.1007/s10780-005-8165-3

Sparks, D., & Loucks-Horsley, S. (1989). Five models of staff development. *Journal of Staff Development, 10*(4), 40-57.

Speck, M., & Knipe, C. (2005). *Why can't we get it right? Designing high-quality professional development for standards-based schools* (2nd ed.). Thousand Oaks, CA: Corwin.

Spencer, J. A., & Jordan, R. K. (1999). Learner-centred approaches in medical education. *British Medical Journal, 318*(3), 1280-1283.

Sperandeo-Mineo, R. M., Fazio, C., & Tarantino, G. (2006). Pedagogical content knowledge development and pre-service physics teacher education: A case study. *Research in Science Education, 36*(3), 235-268. doi: 10.1007/s11165-005-9004-3

Stake, R. E. (2010). *Qualitative research: Studying how things work.* New York, NY: Guilford Press.

Stamatel, J. P. (2003). *Contemporary Hispanic biography*. Retrieved from http://www.encyclopedia.com/topic/Jaime_Escalante.aspx

Stanulis, R. N., Little, S., & Wibbens, E. (2012). Intensive mentoring that contributes to change in beginning elementary teachers' learning to lead classroom discussions. *Teaching and Teacher Education, 28*(1), 32-43. doi: 10.1016/j.tate.2011.08.007

Steele, N. A. (2010). Three characteristics of effective teachers. *Applications of Research in Music Education, 28*(2), 71-78. doi: 10.1177/8755123310361769

Stewart, D. W., Rook, D. W., & Shamdasani, P. N. (2007). *Focus groups: Theory and practice* (2nd ed.). London, England: Sage.

Stiggins, R. J. (1992). High quality classroom assessment: What does it really mean? *Educational Measurement: Issues and Practice, 11*(2), 35-39. doi: 10.1111/j.1745-3992.1992.tb00241.x

Stronge, J. H. (2007). *Qualities of effective teachers* (2nd ed.). Alexandria, VA: Association for Supervison and Curriculum Development.

Stronge, J. H., Tucker, P. D., & Hindman, J. L. (2004). *Handbook for qualities of effective teachers*. Alexandria, VA: Association for Supervision and Curriculum Development.

Stronge, J. H., Ward, T. J., & Grant, L. W. (2011). What makes good teachers good? A cross-case analysis of the connection between teacher effectiveness and student achievement. *Journal of Teacher Education, 62*(4), 339-355. doi: 10.1177/0022487111404241

Sullivan, B. (1999). *The linchpin of teacher quality*. Retrieved from http://www.ascd.org/publications/newsletters/policy-priorities/aug99/num18/toc.aspx

Supovitz, J. A., & Christman, J. B. (2003). *Developing communities of instructional practice: Lessons for Cincinnati and Philadelphia*. Retrieved from http://www.cpre.org/images/stories/cpre_pdfs/rb39.pdf

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980. doi: 10.1002/1098-2736(200011)37:9<963::aid-tea6>3.0.co;2-0

Sydney, M. G. V. (2008). *Opportunities and challenges of using ODL in training secondary school licenced teachers for education programmes: Experiences* *from the Open University of Tanzania*. Retrieved from http://wikieducator.org/images/4/45/PID_671.pdf

Tabulawa, R. (2003). International aid agencies, learner-centred pedagogy and political democratisation: A critique. *Comparative Education, 39*(1), 7-26.

Tam, M. (2000). Constructivism, instructional design, and technology: Implication for transforming distance learning. *Educational Technology and Society, 3*(2). Retrieved from http://www.ifets.info/journals/3_2/tam.html

Tamir, P. (1988). Subject matter and related pedagogical knowledge in teacher education. *Teaching and Teacher Education, 4*(2), 99-110. doi: 10.1016/0742-051x(88)90011-x

Tanzania Institute of Education. (2009). *Physics pedagogy syllabus for diploma in secondary education*. Dar es Salaam, Tanzania: Ministry of Education and Vocational Training.

Tarnoczi, J. (2006). Critical reflections on professional learning communities in Alberta. *Electronic Journal of Sociology*. Retrieved from http://www.sociology.org/content/2006/tier2/tarnoczi.html

Taylor-Powell, E., & Renner, M. (2003). *Analyzing qualitative data*. Retrieved from http://learningstore.uwex.edu/assets/pdfs/g3658-12.pdf

Teddlie, C., & Yu, F. (2007). Mixed methods sampling. *Journal of Mixed Methods Research, 1*(1), 77-100. doi: 10.1177/2345678906292430

Thomas, C., Sevin, C., Morris, G., Harari, C., Stucke, P., Rodwell, J., & Bick, M. (2008). *General education practices for teaching in Tanzania*. Retrieved from http://pctanzania.org/education

Thompson, J., Licklider, B., & Jungst, S. (2003). Learner-centered teaching: Postsecondary strategies that promote "thinking like a professional". *Theory into Practice, 42*(2), 133-141. doi: 10.1207/s15430421tip4202_7

Thompson, P. (2013). Learner-centred education and ‘cultural translation’. *International Journal of Educational Development, 33*(1), 48-58. doi: 10.1016/j.ijedudev.2012.02.009

Thompson, S., Greer, J. G., & Greer, B. B. (2004). *Highly qualified for successful teaching: Characteristics every teacher should possess*. Retrieved from http://www.usca.edu/essays/vol102004/thompson.pdf

Thompson, T. (2008). Mathematics teachers' interpretation of higher-order thinking in Bloom's taxonomy. *International Electronic Journal of Mathematics Education, 3*(2), 96-109.

Thorne, S. (2000). Data analysis in qualitative research. *Evidence Based Nursing, 3*(3), 68-70. doi: 10.1136/ebn.3.3.68

Till, J., Ferkins, L., & Handcock, P. (2011). Physical activity based professional development for teachers: The importance of whole school involvement. *Health Education Journal, 70*(2), 225-235. doi: 10.1177/0017896910396218

Timperley, H. (2008). *Teacher professional learning and development*. Retrieved from http://www.orientation94.org/uploaded/MakalatPdf/Manchurat/EdPractices_18.pdf

Timperley, H., Wilson, A., Barrar, H., & Fung, I. (2008). *Teacher professional learning and development: Best evidence synthesis iterative*. Retrieved from http://www.educationcounts.govt.nz/__data/assets/pdf_file/0017/16901/TPLandDBESentire.pdf

Tobin, G. A., & Begley, C. M. (2004). Methodological rigour within a qualitative framework. *Journal of Advanced Nursing, 48*(4), 388-396. doi: 10.1111/j.1365-2648.2004.03207.x

Tracy, S. J. (2010). Qualitative quality: Eight "big-tent" criteria for excellent qualitative research. *Qualitative Inquiry, 16*(10), 837-851. doi: 10.1177/1077800410383121

Trowbridge, L. W., Bybee, R. W., & Carlson-Powell, J. (2004). *Teaching secondary school science: Strategies for developing scientific literacy*. Thousands Oaks, CA: Merrill Prentice Hall.

Tynjälä, P. (1999). Towards expert knowledge? A comparison between a constructivist and a traditional learning environment in the university. *International Journal of Educational Research, 31*(5), 357-442. doi: 10.1016/s0883-0355(99)00012-9

United Nations Education Scientific and Cultural Organization. (1990). *World declaration on education for all and framework for action to meet basic* *learning needs*. Retrieved from http://www.unesco.org/education/pdf/JOMTIE_E.PDF

United Nations Education Scientific and Cultural Organization. (2000). *The Dakar framework for action education for All: Meeting our collective commitments*. Retrieved from http://unesdoc.unesco.org/images/0012/001202/120240e.pdf

United Nations Education Scientific and Cultural Organization. (2007). *A human rights-based approach to education for all*. Retrieved from http://www.unicef.org/publications/files/A_Human_Rights_Based_Approach_to_Education_for_All.pdf

United Republic of Tanzania. (1999). *The Tanzania development vision 2025*. Dar es Salaam, Tanzania: Author.

United Republic of Tanzania. (2009). *Poverty and human development report: Research and analysis working group MKUKUTA monitoring system*. Retrieved from http://hdr.undp.org/en/reports/nationalreports/africa/tanzania/Tanzania_PHDR_2009.pdf

United States Department of Education. (2004). *Alternative routes to teacher certification*. Retrieved from http://www2.ed.gov/admins/tchrqual/recruit/altroutes/report.pdf

Usak, M., Ozden, M., & Eilks, I. (2011). A case study of beginning science teachers' subject matter (SMK) and pedagogical content knowledge (PCK) of teaching chemical reaction in Turkey. *European Journal of Teacher Education, 34,* 407-429. doi: 10.1080/02619768.2011.592977

Van Driel, J. H., & Berry, A. (2010). Pedagogical content knowledge. In P. Peterson, E. Baker & M. Barry (Eds.), *International encyclopedia of education* (3rd ed., Vol. 8, pp. 656-661). Oxford, England: Elsevier.

Van Driel, J. H., & Berry, A. (2012). Teacher professional development focusing on pedagogical content knowledge. *Educational Researcher, 41*(1), 26-28. doi: 10.3102/0013189x11431010

Van Driel, J. H., Verloop, N., & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching,* *35*(6), 673-695. doi: 10.1002/(sici)1098-2736(199808)35:6<673::aid-tea5>3.0.co;2-j

van Es, E. A. (2012). Examining the development of a teacher learning community: The case of a video club. *Teaching and Teacher Education, 28*(2), 182-192. doi: 10.1016/j.tate.2011.09.005

Vasquez, J. A. (2008). *Tools and traits for highly effective science teaching, K-8*. Retrieved from http://www.heinemann.com/shared/onlineresources%5CE01100%5CVasWebSam3_3_08.pdf

Vavrus, F. (2002). Postcoloniality and english: Exploring language policy and the politics of development in Tanzania. *TESOL Quarterly, 36*(3), 373-397. doi: 10.2307/3588418

Vavrus, F. (2009). The cultural politics of constructivist pedagogies: Teacher education reform in the United Republic of Tanzania. *International Journal of Educational Development, 29*(3), 303-311. doi: 10.1016/j.ijedudev.2008.05.002

Vavrus, F., & Moshi, G. (2009). The cost of a ‘free’ primary education in Tanzania. *International Critical Childhood Policy Studies, 2*(1), 31-42.

Vavrus, F., Thomas, M., & Bartlett, L. (2011). *Ensuring quality by attending to inquiry: Learner-centred pedagogy in Sub-Saharan Africa*. Retrieved from http://www.eng.unesco-iicba.org/sites/default/files/Fundamentals%204%20Eng.pdf

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education, 24*(1), 80-91. doi: 10.1016/j.tate.2007.01.004

Villegas-Reimers, E. (2003). *Teacher professional development: An international review of the literature*. Paris, France: UNESCO International Institute for Educational Planning.

Vuzo, M. (2010). Exclusion through language: A reflection on classroom discourse in Tanzanian secondary schools. *Papers in Education and Development, 29*, 14-36.

Walczyk, J. J., & Ramsey, L. L. (2003). Use of learner-centered instruction in college science and mathematics classrooms. *Journal of Research in Science Teaching, 40*(6), 566-584. doi: 10.1002/tea.10098

Wallendorf, M., & Belk, R. W. (1989). Assessing trustworthiness in naturalistic consumer research. *Association for Consumer Research*, 69-84. Retrieved from http://www.acrwebsite.org/volumes/display.asp?id=12177

Walls, R. T., Nardi, A. H., von Minden, A. M., & Hoffman, N. (2002). The characteristics of effective and ineffective teachers. *Teacher Education Quaterly*, *29*(1), 39-48.

Walsh, K. (2001). *Teacher certification reconsidered: Stumbling for quality*. Retrieved from http://www.nctq.org/p/publications/docs/ed_cert_1101_20071129024241.pdf

Walsh, K., & Jacobs, S. (2007). *Alternative certification isn't alternative*. Retrieved from http://www.nctq.org/p/tqb/docs/Alternative_Certification_Isnt_Alternative_20071113021230.pdf

Ware, S. A. (1992). *The education of secondary science teachers in developing countries*. Washington, DC: World Bank.

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research, 73*(1), 89-122. doi: 10.3102/00346543073001089

Wayne, A. J., Yoon, K. S., Zhu, P., Cronen, S., & Garet, M. S. (2008). Experimenting with teacher professional development: Motives and methods. *Educational Researcher, 37*(8), 469-479. doi: 10.3102/0013189x08327154

Weaver, K., & Olson, J. K. (2006). Understanding paradigms used for nursing research. *Journal of Advanced Nursing, 53*(4), 459-469. doi: 10.1111/j.1365-2648.2006.03740.x

Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research, 79*(2), 702-739.

Wedgwood, R. (2007). Education and poverty reduction in Tanzania. *International Journal of Educational Development, 27*(4), 383-396. doi: 10.1016/j.ijedudev.2006.10.005

Weimer, M. (2002). *Learner-centered teaching: Five key to changes to practice*. San Francisco, CA: Jossey-Bass.

Wenger, E. (2006). *Communities of practice: A brief introduction*. Retrieved from http://www.ewenger.com/theory/

Westchester Institute for Human Services Research. (2007). *The balanced views: Professional development*. Retrieved from http://www.sharingsuccess.org/code/bv/pd.hml

Wheatley, G. H. (1991). Constructivist perspectives on science and mathematics learning. *Science Education, 75*(1), 9-21. doi: 10.1002/sce.3730750103

Whitehurst, G. J. (2002, March). *Scientifically based research on teacher quality: Research on teacher preparation and professional development*. Paper presented at the White House Conference on Preparing Tomorrow's Teachers, Washington, DC. Retrieved from http://www.stcloudstate.edu/tpi/initiative/documents/assessment/Scientifically%20Based%20Reserach%20on%20Teacher%20Quality.pdf

Wilson, B., & Myers, K. (2000). Situated cognition in theoretical and practical context. In D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments* (pp. 57-88). Mahwah, NJ: Lawrence Erlbaum Associates.

Wilson, R. C., Dienst, E. R., & Watson, N. L. (1973). Characteristics of effective college teachers as perceived by their colleagues. *Journal of Educational Measurement, 10*(1), 31-37. doi: 10.1111/j.1745-3984.1973.tb00779.x

Wohlfarth, D., Sheras, D., Simon, B., Pimentel, J. H., & Gabel, L. E. (2008). Student perceptions of learner-centered teaching. *A Journal of Scholarly Teaching, 3*, 67-74.

Wood, D. (1997). Continuing professional development through a regional network. *Management in Education, 11*(5), 22. doi: 10.1177/089202069701100513

Woolnough, B. E. (1994). *Effective teaching science*. Buckingham, England: Open University Press.

Wray, K. B. (2011). Kuhn and the discovery of paradigms. *Philosophy of the Social Sciences, 41*(3), 380-397. doi: 10.1177/0048393109359778

Wright, P., Horn, S., & Sanders, W. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of Personnel Evaluation in Education, 11*(1), 57-67. doi: 10.1023/A:1007999204543

Yager, R. E., Hidayat, E. M., & Penick, J. E. (1988). Features which separate least effective from most effective science teachers. *Journal of Research in Science Teaching, 25*(3), 165-177. doi: 10.1002/tea.3660250302

Yardley, L., & Joffe, H. (2004). Content and thematic analysis. In D. F. Marks & L. Yardley (Eds.), *Research methods for clinical and health psychology* (pp. 56-68). London, England: Sage.

Yin, R. K. (1981). The case study crisis: Some answers. *Administrative Science Quarterly, 26*(1), 58-65.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

Yip, D. Y. (2003). *The effects of the medium of instruction on science learning of Hong Kong secondary students.* (Doctoral dissertation), University of Nottingham, Nottingham, England. Retrieved from http://etheses.nottingham.ac.uk/2247/1/251347.pdf

Yip, D. Y., Tsang, W. K., & Cheung, S. P. (2003). Evaluation of the effects of medium of instruction on the science learning of Hong Kong secondary students: Performance on the science achievement test. *Bilingual Research Journal, 27*(2), 295-331. doi: 10.1080/15235882.2003.10162808

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. L. (2007). *Reviewing the evidence on how teacher professional development affects student achievement*. Retrieved from http://ies.ed.gov/ncee/edlabs/regions/southwest/pdf/rel_2007033.pdf

Young, J. R., Bullough, R. V., Draper, R. J., Smith, L. K., & Erickson, L. B. (2005). Novice teacher growth and personal models of mentoring: Choosing compassion over inquiry. *Mentoring and Tutoring, 13*(2), 169–188. doi: 10.1080/13611260500105477

Zeichner, K. M., & Schulte, A. K. (2001). What we know and don't know from peer-reviewed research about alternative teacher certification programs. *Journal of Teacher Education, 52*(4), 266-282. doi: 10.1177/0022487101052004002

Zumwalt, K. (1996). Simple answers: Alternative teacher certification. *Educational Researcher*, *25*(8), 40-42.

Zuzovsky, R. (2011). *Teachers' qualifications and their impact on student achievement: Findings from TIMSS 2003 data for Israel*. Retrieved from http://www.ierinstitute.org/IERI_Monograph_Volume_02_Chapter_02.pdf

APPENDICES

Appendix 1: Research clearance request letter

Centre for Science and Technology Education Research

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Ph: 64-7-838 4035 (Centre direct line)
Fax: 64-7-838 4272
Email: cster@waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

The Permanent Secretary,
Ministry of Education and Vocational Training,
P.O. Box 9121,
Dar es Salaam.
Tanzania.
31/03/2011

u.f.s

The Director
Centre for Science and Technology Education Research,
Private Bag 3105,
Hamilton 3240, New Zealand.

RE: Permit for conducting research in Tanzania Secondary schools.

Reference is made to the above heading. Currently I am a Doctoral student at the University of Waikato, New Zealand; and a member of the Academic Staff at the University of Dar Es Salaam, School of Education, Tanzania.

I am requesting permission to conduct a research study in secondary schools in the Manyara Region, Babati District. My research is entitled "Supporting Licensed Science Teachers Professional Development (PD) in Adopting Learner-Centred Pedagogy in Tanzania Secondary Schools". The purpose of this project is to: identify and assess the professional learning needs of licensed science teachers; examine the strength and weaknesses of current professional development (PD) and evaluate the practices of licensed teachers in adopting learner-centred teaching strategies in the classrooms. Also, the study intends to develop and implement a PD intervention for licensed science teachers in the selected schools to meet identified learning needs of these teachers. This study will be conducted for one year, from 1st April, 2011 to 30th May, 2012.

I hope the study will have positive policy, practical and research implications for the Tanzania education system, particularly for improving the status of science education in community secondary schools. The study will involve six (6) licensed science teachers in two different secondary schools in in-depth interviews, focus group discussion, and classroom observations. Also, two (2) headmasters/mistresses of these schools, and one (1) District educational officer and one (1) Ward educational officer will be interviewed. Teachers' schemes of work, lessons plans and student assessments will be examined and analysed. The teachers will also be involved in a PD intervention that will be conducted in their respective schools to enhance pedagogical content knowledge learning needs identified by the researcher.

The PD intervention will be carefully designed so that normal school routines are not affected in the whole process of research. The research data collected will be used for writing a research report for my thesis leading to the award of a PhD in science education from the University of Waikato, New Zealand. Also, the results can be used in seminar presentation, conferences, and publications in journal articles.

The study will strictly follow all requirements of University of Waikato Human research Ethics regulation 2008, and the ethical guidelines of the New Zealand Association for Research in Education (NZARE).The participants' names and names of schools will remain anonymous and confidential. The raw data will be kept in a secure place and will be accessed only by researcher and the supervisors of the project. The participants of the study will have the right to withdraw from the study at any stage. If the permission is given to proceed, all participants will be asked for informed consent.

You may contact me at +64 7 838446 ex 8923 or at vna1@waikato.ac.nz, or my supervisors Dr Anne Hume at +64 7 8384466 ext 7880 or at Email: annehume@waikao.ac.nz ; or Prof. Richard Coll at +64 7 838 4100 or at Email: r.coll@waikato.ac.nz, if you have question related to this study.

Thank you very much for your consideration of my request and I look forward to your reply.

....

Vicent Naano Anney

Appendix 2: Authorization access letters from Ministry of Education and Vocational Training

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION AND VOCATIONAL TRAINING

Cable: "ELIMU" DAR ES SALAAM
Telex: 41742 Elimu Tz.
Telephone: 2121287, 2110146
Fax: 2127763

Post Office Box 9121
DAR ES SALAAM

In reply please quote:

Ref. ED/EP/ERC/VOL IV/ 24

Date: Friday, April 29, 2011

The Regional Administrative Secretary; Manyara region.

(ATT. Regional Education Officer)

RE: RESEARCH CLEARANCE FOR MR. VICENT NAANO ANNEY

The mentioned is bonafide PhD student of the University of **Waikato** and a Member of staff at the **University of Dar es Salaam,** School of Education. The student is conducting research titled "**Supporting Licensed Science Teachers Professional Development (PD) in Adopting Learner-Centred Pedagogy in Tanzania Secondary Schools"** as part of his Doctoral dissertation in Scince Teacher Education.

The researcher needs to collect data and necessary information related to the research topic in sampled Secondary schools in the region.

In line with the above information you are being requested to provide the needed assistance that will enable him to complete this study successfully. The period by which this permission has been granted is from **29th April 2011 to 30th May, 2012.**

By Copy of This Letter, **Mr. Vicent Naano Anney** is required to submit a copy of the report (or part of it) to *the Permanent Secretary, Ministry of Education and Vocational Training* for documentation and reference.

Yours truly,

Abdallah S. Ngodu
For Permanent Secretary

CC: Mr. Vicent Naano Anney-University of Waikato, Private Bag 3105, Humilton, New Zealand

Appendix 3: Authorization letter from Regional Administrative Office to access schools

THE UNITED REPUBLIC OF TANZANIA
THE PRIME MINISTRE'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

Tel. No. 027-2530267
027-2530237
027-2530281
027-2530317
Fax No. 027-2530294

Regional Commissioner's Office,
Manyara Region,
P.O. Box 310,
BABATI.

E.mail: *rcmanyara@habari.habari.co.tz*
In reply please quote:

Ref. No.FA.262/347/01/117 **9th May, 2011**

District Administrative Secretaries,
Manyara Region

RE: RESEARCH CLEARANCE FOR MR. VICENT NAANO ANNEY

We wish to introduce you to **Mr. Vicent Naano Anney** who is a PHD student from Waikato University and member of Dar es Salaam University, school of education. The title of the research is **'Supporting Licensed Science Teachers Profession Development (PD) in Adopting Learner-Centered Pedagogy in Tanzania Secondary Schools''** as part of his Doctoral Dissertation in Science Teacher Education.

The above named has been granted permission to conduct his research in all Manyara region districts.

The period for which this permission has been granted is from ***29th April, 2011 to 30thMay, 2012.***

Please, accord him necessary support.

G. w. Mjema
For: **Regional Administrative Secretary**
MANYARA REGION

C.C: **Mr. Vicent Naano Anney**

Appendix 4: Authorization letters from District Administrative Officer also to access schools

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA WAZIRI MKUU
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Simu No. *027 2531035*
027 2531071
Fax No. *027 2530705*

Ofisi ya Mkuu wa Wilaya,
Wilaya ya Babati,
S .L.P. 11,
Babati.

Unapojibu tafadhali taja:

Kumb. Na. DC/BBT/R.30/VOL11/38 **10 Mei, 2011**

Mkurugenzi wa Mji,
Halmashauri ya Mji,
Babati.

Mkurugenzi wa Wilaya,
Halmashauri ya Wilaya,
Babati.

YAH: UTAFITI

Ninamtambulisha kwenu Bwana Vicent N. Anney, mwanafunzi wa PHD katika Chuo Kikuu cha Waikato (New Zealand) na ambaye pia ni mhadhiri wa Chuo Kikuu cha Dar Es Salaam anayeomba kufanya utafiti juu ya **"Supporting Licensed Science Teachers Profession Development (PD) in Adopting Learner – Centered Pedagogy in Tanzania Secondary School".**

Tafadhali mpokeeni na kumpa ushirikiano ili kukamilisha utafiti huo kwa ufanisi.

P. F. Mollel
Kny: KATIBU TAWALA WILAYA
BABATI

Nakala:
- Bwana Vicent N. Anney.

Appendix 5: District Education Officer Authorization letter to access schools

HALMASHAURI YA MJI WA BABATI

(*Barua zote ziandikwe kwa Mkurugenzi wa Mji*)

Simu Na: *(027)(253 0565)*
Fax Na: *(027)(253 0565)*

Unapojibu tafadhali taja

HALMASHAURI YA MJI BABATI TOWN COUNCIL

UKUMBI WA MJI,
S. L. P. 383,
BABATI.

Kumb: Na. BTC/A.40/16VOL.I/126

Tarehe: 23.06.2011

Wakuu wa Shule,
Shule za Sekondari,
Halmashauri ya Mji,
S.L.P. 383,
BABATI.

YAH: KUMTAMBULISHA NDG. VICENT N. ANNEY

Rejea somo tajwa hapo juu.

Ninamtambulisha kwenu Ndg. Vicent N. Anney ambaye ni mwanafunzi wa PHD katika Chuo Kikuu cha Waikato (New Zealand) pia ni Mhadhiri wa Chuo Kikuu cha Dar es Salaam.

Tafadhali mpeni ushirikiano wa kazi yake ya Utafiti mara afikapo Shuleni kwenu.

Nawatakia utekelezaji mwema.

Semvua R. Msoffe
Kny: AFISA ELIMU SEKONDARI
HALMASHAURI YA MJI
BABATI

Nakala:
Mkurugenzi wa Mji - Aione kwenye jalada.
Babati.

Appendix 6: Invitation letters for schools

The University of Waikato,
Centre for Science and
Technology Education Research,
Private Bag 3105,
Hamilton 3240, New Zealand.

The Headmasters/headmistress

____

Dear Sir/Madam

RE: Participation of your school in a research study

I am requesting your permission to include your school in a sample of schools to be involved in a study titled "Supporting Licensed Science Teachers Professional Development in Adopting Learner-Centred Teaching Pedagogy in Tanzanian Secondary Schools". The purpose of this project is to: identify and assess the professional learning needs of licensed science teachers; examine the strength and weaknesses of current professional development and evaluate the practices of licensed teachers in adopting learner-centred teaching strategies in the classrooms. Also, the study intends to develop and implement a professional development intervention for licensed science teachers in the selected schools to meet identified learning needs of these teachers. This study will be conducted over two years, from April, 2011 to April, 2013.

The study will involve three (3) licensed science teachers from your school in in-depth interviews, focus group discussion, and classroom observations. The research data collected will be used for writing a research report for my doctoral thesis leading to the award of a PhD in science education of the University of Waikato, New Zealand. Also, the results can be used in seminar presentation, conferences, and publications in journal articles.

The study will strictly follow all the requirements of the University of Waikato Human Research Ethics Regulation 2008, and the ethical guidelines of the New Zealand Association for Research in Education (NZARE). The participants' names and names of the schools will remain anonymous and confidential, and raw data will be kept in a secure place and it will be only accessed by the researcher and supervisors of the project.

Kind Regards

Vicent Naano Anney

Appendix 7: Teachers' invitation letter

The University of Waikato,
Centre for Science and Technology
Education Research,
Private Bag 3105,
Hamilton 3240, New Zealand.

Dear teacher,

My name is Vicent Naano Anney. I am a doctoral candidate in the Center for Science and Technology Education Research at the University of Waikato. I am conducting a research study as part of the requirements of my PhD degree in Science education, and I would like to invite you to participate.

The purpose of this project is to: identify and assess the professional learning needs of licensed science teachers; examine the strength and weaknesses of current professional development and evaluate the practices of licensed teachers in adopting learner-centred teaching strategies in the classrooms. Also, the study intends to develop and implement a professional development intervention for licensed science teachers in the selected schools to meet identified learning needs of these teachers. This study will be conducted over two years, from April, 2011 to April, 2013. I will conduct six (6) classrooms observations: three (3) classroom observations before and after professional development intervention, followed by face-to-face individual interviews, and a focus group discussion with other teachers. Also, you will participate in the professional development intervention that will involve peer discussion, reading learner-centred materials, co-teaching, and reflecting the learned learner-centred materials.

The classroom observation, interview session and focus group discussion will be audiotaped so that I can accurately reflect on what we discussed. The tapes will only be reviewed by me, my supervisors and the transcriber. Participation in the study is confidential and your participation will not have any negative impact on the status of your employment. Data from the study will be kept in a secure location at the

University of Waikato. The data collected will only be used for thesis writing, and it may also be published or presented at professional meetings, but your identity will not be revealed and pseudonyms will be used in analysis and in the work that will be published as a result of this study.

Your participation in this study is voluntary. You may also withdraw from the study at any time if you wish to do so or decline to answer any questions you are not comfortable with. You may contact me at +64 7 838446 ex 8923 and vna1@waikato.ac.nz, or my supervisors Dr Anne Hume at +64 7 8384466 ext 7880, Email: annehume@waikao.ac.nz ; or Prof. Richard Coll at +64 7 838 4100, Email: r.coll@waikato.ac.nz, if you have study related questions or problems. If the issue is not resolved please contact Dr Chris Eames at C.eames@waikato.nz.

Thank you for your consideration

Vicent Naano Anney

Appendix 8: Participant's informed consent form

I am aware that my participation in this study is voluntary. I understand the intent and purpose of this research. If, for any reason, at any time, I wish to stop the interview and focus group discussion, I may do so without having to give an explanation. The researcher has reviewed the individual and social benefits and risks of this project with me. As a participant I have the right to review, comment on, and/or withdraw information before the end of data gathering phase

The data gathered in this study are confidential with respect to my personal identity unless I specify otherwise. By signing below and returning this form, I am consenting to participate in this project via face-to-face interview/focus group discussion, classroom observation as designed by the project researcher.

Participant name ___________________Signature__________ Date: ____________

Please keep a copy of this consent form for your record. If you have other questions concerning your participation in this project, please contact me or my supervisors using the following contact address: Dr Anne Hume, Email: annehume@waikao.ac.nz , Ph: +64 7 8384466 ext 7880; or Prof Richard Coll, Email: r.coll@waikato.ac.nz, Ph: +64 7 838 4100.

Thank you very much.

Appendix 9: Professional development study materials used during the intervention

Expected learning outcomes of the professional development intervention

At the end of this professional development intervention the licensed science teachers will be able to:

i. Describe and apply different knowledge-based categories for science teaching
ii. Elaborate why PCK is an important knowledge base for teaching science and student learning
iii. Develop pedagogical and didactical skills including logical organization of ideas and addressing pupils’ misconceptions during classroom teaching
iv. Reflect critically on different conceptions of teaching and learning science
v. Choose and describe various teaching approaches appropriate for learners and situations both indoors and outdoors and in laboratory settings
vi. Critically analyse the subjects they teach and evaluate their teaching for the purpose of making them reflective practitioners
vii. Demonstrate teamwork working as part of a professional learning community to develop their PCK
viii. Acquire an attitude of working as a community of science teachers
ix. Develop skills for preparing and using a reflective journal in teaching science
x. Develop and use teaching portfolios as part of professional growth
xi. Develop and teach lessons using a learner-centred approach
xii. Demonstrate and use formative assessment in their daily classroom teaching
xiii. Enable each licensed science teacher to prepare good schemes of work and lessons plan for science subjects
xiv. To develop skills for assessing, testing, marking and giving feedback to learners.
xv. Describe the nature of science, how science works, and how science is taught in school
xvi. Tentatively to develop their own pedagogical content knowledge

Module 1: Professional learning community for science teachers

A. Learning units

- What is a professional learning community
- Characteristics of a professional learning community
- Advantages of a professional learning community in addressing teachers' PCK needs and students' learning outcomes

B. Delivery mode activities

- Licensed science teachers' group work presentation (after reading articles relating to professional learning communities)
- Discussion of selected science topic to identify students possibly naive (misconceptions) ideas
- Licensed science teacher(s) will prepare a demonstration lesson and will be critically examined as a professional learning community of science teachers
- Power point presentation (researcher)

C. Teaching and learning resources

DuFour, R. (2004). What is a professional learning community? *Educational Leadership, 61*(8), 6-11.

Hord, S. M. (2009). Professional learning communities: Educators work together with the shared purpose of improving students' learning. *Journal of Staff Development*, *30*(1), 40-43.

Sargent, T. C., & Hannum, E. (2009). Doing more with less: Teachers' professional learning communities in resource-constrained primary schools in rural China. *Journal of Teacher Education*, *60*(3), 258-276. doi: 10.1177/0022487109337279

Module 2: Lessons planning

A. *Learning Units*

- Formulating specific learning objectives and use of correct action verbs (Blooms Taxonomy)
- Preparing a lesson plan and developing teaching notes
- Selecting a teaching approach and selecting/preparing teaching resources
- How will the lesson be assessed in terms of the intended objectives, teachers' competence and students' achievement?
- Examining verbal presentation skills-loudness of voice, positioning, movement, mannerisms, questioning strategy including the use of waiting time and reinforcement.

B. Delivery mode activities

- Developing a lesson plan sample individually
- Teaching the prepared lesson to the group
- Discussion on the ways of improving the presented lesson
- Writing a reflection of the presented lesson(s) in the reflective journal

C. *Learning and teaching resources*

Kizlik, B. (2011). *Six common mistakes in writing lesson plans (and what to do about them)*. Retrieved from http://www.adprima.com/mistakes.htm

Ministry of Education and Vocational Training. (2007). *Chemistry syllabus for ordinary secondary education Form I-V*. Dar es Salaam Tanzania: Author.

Ministry of Education and Vocational Training. (2007). *Physics syllabus for ordinary secondary education Form I-V*. Dar es Salaam, Tanzania: Author.

Ministry of Education and Vocational Training. (2008). *Biology syllabus for ordinary secondary education Form I-V*. Dar es Salaam, Tanzania: Author

Module 3: Categories of knowledge base of teaching science

A. Learning units

- To explore different knowledge-based categories for teaching science
- To explore the major sources for knowledge-based teaching
- Learn how to use the aspects of pedagogical reasoning in teaching selected science topics and identifying important knowledge categories.

B. Delivery mode

- Each licensed teacher will be given the articles to read and in groups of two they will summarize important concepts in the article.
- Each group will present a summary of the articles for workshop discussion
- Co-teaching of selected topics in science subjects (physics, biology and chemistry) and identify some knowledge-based categories

C. Teaching and learning resources for this module

Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher, 31*(5), 3-15. doi: 10.3102/0013189x031005003

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22

Verloop, N., Van Driel, J., & Meijer, P. (2001). Teacher knowledge and the knowledge base of teaching. *International Journal of Educational Research, 35*(5), 441-461. doi: 10.1016/s0883-0355(02)00003-4

Module 4: Nature of science

A. Leaning units

- What is science and what is scientific method?
- Why teach, and why learn, science?
- How we teach and learn science

B. Delivery mode activities

- Group work presentation on the summary of articles on the nature of science
- Licensed science teachers to work in groups and identify how they best teach the selected science topic.
- Power point presentation

C. *Teaching and learning resources*

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching, 44*(5), 653-680. doi: 10.1002/tea.20159

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359. doi: 10.1002/tea.3660290404

Model 5: The conceptions of teaching and learning science

A. *Leaning Units*

- Exploring the conceptions of teaching science
- Explore approaches for teaching and learning science
- Examining the concept of "teaching" and learning (ie is it to promote transmission, interaction, or transformation, is it an art or a science?)
- Describing and demonstrating interactive and transformative approaches to teaching (group tasks, plenary discussions, whole class tasks, panel discussions, debates, games, simulations, online instruction/e learning, role playing, dramatization, case studies, independent project etc.)

B. *Delivery mode activity*

- Group work reading and presenting summary of the articles.
- Demonstration teaching conception by micro-teaching of selected topics in science subjects
- Power point presentation

C. *Teaching and learning resources*

Boulton-Lewis, G. M., Smith, D. J. H., McCrindle, A. R., Burnett, P. C., & Campbell, K. J. (2001). Secondary teachers' conceptions of teaching and learning. *Learning and Instruction, 11*(1), 35-51. doi: 10.1016/s0959-4752(00)00014-1

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education, 37*(1), 57-70. doi: 10.1023/a:1003548313194

Module 6: Reflective practice in teaching science

A. Learning units

- Exploring the meaning of a reflective journal
- Learning to reflect on practice
- Developing a reflective journal
- How to use “EXPLORE’ as reflective techniques. EXPLORE is an acronym for "Examine," "Pair," "Listen," "Organize," "Research," and "Evaluate."

B. Delivery mode

- Licensed science teachers will conduct a workshop presentation after reading journal articles about reflective journals
- Licensed teachers will develop reflective journals for their subjects

C. Learning and teaching resources

Boud, D. (2001). Using journal writing to enhance reflective practice. *New Directions for Adult and Continuing Education, 2001*(90), 9-18. doi: 10.1002/ace.16

Francis, D. (1995). The reflective journal: A window to pre-service teachers' practical knowledge. *Teaching and Teacher Education, 11*(3), 229-241. doi: 10.1016/0742-051x(94)00031-z

Woodward, H. (1998). Reflective journals and portfolios: Learning through assessment. *Assessment and Evaluation in Higher Education, 23*(4), 415 - 423.

Module 7: Portfolio as an assessment tool for science teachers

A. Learning units

- Explaining the meaning of teaching portfolios
- Discuss the content of science teaching portfolios
- Purpose and uses of science teaching portfolios
- Explore how to promote reflective science teaching through the use of teaching portfolios
- Strategies for organizing science teaching portfolios

B. Delivery mode

- Power point presentation (research and participants)
- Developing science teaching portfolios
- Developing a summary from journal articles about teaching portfolios

C. Learning and teaching resources for this module

Loughran, J., & Corrigan, D. (1995). Teaching portfolios: A strategy for developing learning and teaching in pre-service education. *Teaching and Teacher Education, 11*(6), 565-577. doi: 10.1016/0742-051X(95)00012-9

Mansvelder-Longayroux, D. D., Beijaard, D., & Verloop, N. (2007). The portfolio as a tool for stimulating reflection by student teachers. *Teaching and Teacher Education, 23*(1), 47-62. doi: 10.1016/j.tate.2006.04.033

Wade, R. C., & Yarbrough, D. B. (1996). Portfolios: A tool for reflective thinking in teacher education? *Teaching and Teacher Education, 12*(1), 63-79. doi: 10.1016/0742-051X(95)00022-C

Module 8: Characteristics of learner-centred teaching

A. Learning unites

- Discuss and illustrate the differences between learner-centred and teacher-centred approaches to teaching
- Characteristics of learner-centred teaching
- Assessment of the student–centred teaching approach
- Practising learner-centred teaching by preparing lesson plan for selected science topic in the curriculum/syllabus

B. Delivery mode

- Workshop presentation
- Micro-teaching of learner-centred science lesson
- Micro-teaching of teacher-centred lesson
- Group discussion of the presented lesson
- Writing reflection of each lesson

D. Teaching and learning resources

Jean, W. P. (2011). Applying learner-centered principles in teacher education. *Theory into Practice*, *42*(2), 127-132. doi: 10.1353/tip.2003.0019

Meece, J. L. (2003). Applying learner-centred principles to middle school education. *Theory into Practice*, *42*(2), 109-116. doi: 10.1207/s15430421tip4202_4

Schuh, K. L. (2004). Learner-centred principles in teacher-centred practices? *Teaching and Teacher Education, 20*(8), 833-846. doi: 10.1016/j.tate.2004.09.008

Module 9: Formative and summative assessment

A. Learning Units

- Discuss and practise formative evaluation through oral and written questioning and observation
- Examine summative as opposed to formative evaluation

- Discuss and illustrate the setting and management of individual and group homework tasks and quizzes/tests.

B. Delivery mode activities

- Reading selected articles on formative and summative assessment
- Teaching a lesson in the classroom and demonstrating formative assessment while teaching
- Workshop presentation (power point presentation)

C. Learning and teaching materials

______. (Undated). *Chapter 3: Formative and summative assessment*. Retrieved from http://amec.glp.net/c/document_library/get_file?p_l_id=781847&folderId=754745&name=DLFE-20967.pdf

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5-31. doi: 10.1007/s11092-008-9068-5

Cowie, B., & Bell, B. (1999). A model of formative assessment in science education. *Assessment in Education: Principles, Policy and Practice, 6*(1), 101 - 116. doi: 10.1080/09695949993026

Appendix 10: Post-professional development intervention reflection questions for licensed science teachers

1. Did the content of the professional development intervention make sense to your teaching practice? Please explain.

………………………………………………………………………………………

2. Was the facilitator knowledgeable and helpful in teaching the professional development content? Explain

………………………………………………………………………………………

3. Were some of your professional development needs met through this professional development intervention? Explain

i. Pedagogical knowledge

………………………………………………………………………………………

ii. Subject content knowledge

………………………………………………………………………………………

iii. Pedagogical content knowledge

………………………………………………………………………………………

4. What are some other ways that the professional development had an important impact on your practice?

………………………………………………………………………………………

5. Did you receive support from your school leadership in implementing the new skills you learned? Explain

………………………………………………………………………………………

6. Did you share the new skills you learned with other science teachers in the school? Explain

………………………………………………………………………………………

7. Did you practice the new skills you learned? Explain with examples

………………………………………………………………………………………

8. What are some other ways that the professional development had an important impact on student outcomes in your classroom?

………………………………………………………………………………………

9. Do you think this professional development programme helped you to develop a teacher network community? Explain

……………………………………………………………………………………………

10. Please describe any impediments (e.g., lack of materials, support, resources, and training) that need to be addressed for consistent and successful implementation to be achieved.

……………………………………………………………………………………………

11. Please describe the strategies you used to make implementation easier or more successful.

……………………………………………………………………………………………

12. General comments:

……………………………………………………………………………………………

Thank you very much for your cooperation

Appendix 11: Licensed science teachers interview guide

1. How long have you been teaching in this school?

   Prompts:

   i. What grade/form do you teach?

   ii. What are your teaching subjects?

2. What challenges are you facing in teaching your subjects?

   Prompts:

   i. What subject content knowledge challenges are you facing?

   ii. What teaching pedagogical/methodological challenges are you facing in lesson preparation?

3. Do you think that the four weeks' induction course offered during your recruitment helped you to become an effective teacher?

   Prompts:

   i. What are the strengths of your induction course?

   ii. What are the weaknesses of your induction course?

4. What kind of training would you like to be available for licensed science teachers?

   Prompts:

   i. What are your professional learning needs?

   ii. Which specific areas of teaching do you think you need more professional help with?

5. How would you describe the current professional development activities for licensed science teachers in terms of: (a). Accessibility? (b). Quality?

   Prompts:

   i. Is the professional development training you received relevant to your own pedagogical learning needs?

   ii. What are the strengths and weaknesses of the current professional development for licensed science teachers?

   iii. What barriers prevent you from receiving professional development training?

6. Did you receive any peer coaching/mentoring to assist you when you started teaching in this school?

Prompts:

i. Do you have any supporting learning materials for your professional learning needs?

ii. Do you receive any support from schools/Ward/District for you professional learning needs?

7. The recent science education curriculum recommended the use of learner-centred teaching strategies for teaching; can you describe some of these strategies?

   Prompts:

   i. Where did you learn these strategies?

   ii. How often are you using learner-centred strategies?

8. What challenges are you facing in teaching lessons using the learner-centered approach?

   Prompts:

   i. What techniques do you use to keep students actively involved during a lesson?

   ii. How would you describe student participation in learner-centred teaching and learning?

9. What assessment strategies do you use for learner-centred instruction in the classroom?

   Prompts:

   i. What techniques do you use to check on students' understanding during a lesson?

10. Would you like to participate in a professional learning intervention to meet the training needs you have identified?

    Prompts:

    i. Elaborate on your answer

11. Would you like to involve other teachers in the ward to participate with you in the professional development intervention?

    Prompts:

    i. Can you elaborate on your answer?

12. What features do you think would help to facilitate science teachers' participation in a professional learning community in the school?

Appendix 12: Interview guide for Headmasters /Headmistress

1. How long have you been working in the capacity of headmaster?
2. How long have you worked in this school?
3. How many licensed teachers do you have in this school?
4. How would you describe licensed teachers' effectiveness in the classrooms?
   Prompts:

i. How often do licensed teachers use learner-centred instruction in the classroom?

ii. Are you satisfied with licensed science teachers' skills in teaching the learner-centred curriculum?

5. What strategies do you have for helping licensed science teachers become effective in the classrooms?
   Prompts:

i. Do you have any school-based professional development programme for assisting licensed teachers in this school (peer coaching, mentoring etc)?

ii. In your opinion what are the pedagogical learning needs of licensed science teachers?

iii. What are the subject content knowledge needs of licensed science teachers?

6. Suggest any strategies that could be useful for developing school-based professional learning communities for science teachers?
7. Do you have any plans in the future to establish school-based professional development programme for licensed teachers in this school? Elaborate on your answer

Appendix 13: Interview guide for Ward Education Officer

1. How long have you been working in the capacity of Ward Education Officer?
2. How long have you worked in this ward?
3. Under the recent education reforms, management of Ward community secondary schools has been decentralized to local communities. In your view, what are the challenges facing the licensed science teachers in the community secondary schools?

   Prompts:

   i. Are you satisfied with the quality of licensed science teachers? Why/why not?

   ii. In your opinion, what are the professional learning needs of licensed science teachers?
4. What strategies do you have at Ward level that could be useful for helping licensed science teachers' professional growth?

   Prompts:

   i. Do you have any professional development programmes for licensed science teachers at ward level?
5. What do you understand by teachers' professional learning communities?

Prompts:

i. Do you have professional learning communities in this ward?

ii. Do you have any future plan for establishing professional learning activities for licensed teachers at ward level?

6. The Ministry of Education in the Teacher Education Master Plan (TEMP) acknowledges the need for developing ward-base teacher professional development programmes. What you think are the challenges of establishing teachers' professional learning communities at ward level?
7. Give you are opinion on any strategies that could be useful for developing ward-based teacher professional learning communities for science teachers?

Appendix 14: Interview guide for District Education Officer

1. How long have you been working in the capacity of District Education Officer?
2. How long have you worked in this District?
3. Under the recent education reforms, management of Ward community secondary schools has been decentralized to local communities. In your view, what are the challenges facing the licensed science teachers in the community secondary schools?

   Prompts:

   i. Are you satisfied with the quality of licensed science teachers? Why/why not?
   ii. In your opinion, what are the professional learning needs of licensed science teachers?
4. What strategies do you have at District level that could be useful for helping licensed science teachers' professional growth?

   Prompts:

   i. Do you have any professional development programmes for licensed science teachers at District level?
5. What do you understand by teachers' professional learning communities?

   Prompts:

   i. Do you have any professional learning communities in this district?
   ii. Do you have any future plans for establishing professional learning communities for teachers at district level?
6. The Ministry of Education in the Teacher Education Master Plan (TEMP) acknowledges the need for developing ward-base teacher professional development programmes. What do you think are the challenges of establishing teachers' professional learning communities

   i. At ward level?
   ii. Schools level?
7. Give your opinion on strategies that could be useful for developing school-based professional learning communities for science teachers?

Appendix 15: Interview guide for School Regional Inspector

1. How long have you been working in the capacity of regional school inspector?
2. How long have you worked in this region?
3. How would you describe licensed teachers' effectiveness in the classrooms?

   Prompts:

   i. How often do licensed teachers use learner-centred instruction in the classroom?

   ii. Are you satisfied with licensed science teachers' skills in teaching the learner-centred curriculum?
4. What strategies do you have for helping licensed science teachers become effective in the classrooms?

Prompts:

i. Do you have any school-based professional development programme for assisting licensed teachers in schools (peer coaching, mentoring etc.)?

ii. In your opinion what are the pedagogical learning needs of licensed science teachers?

5. What are the subject content knowledge training needs of licensed science teachers?
6. Suggest any strategies that could be useful for developing school-based professional learning communities for science teachers.
7. Do you have any plans in the future to establish a school-based professional development programme for licensed teachers? Elaborate on your answer

Appendix 16: Focus group discussion guide before the professional development intervention

1. What professional challenges are you facing in teaching your subjects?
2. What is your opinion on the four-week induction course offered during your recruitment to help licensed science teachers acquire classroom teaching skills?
3. Can you share with me the strengths and weaknesses of the current professional development programmes for licensed science teachers?
4. Describe the training needs you think are important for helping licensed science teachers' professional growth.
5. What do you understand by the term pedagogical content knowledge? Do you understand the potential of pedagogical content knowledge for science teachers? Elaborate on your answer
6. What challenges do you face in teaching lessons using the leaner-centered teaching approach?
7. Can you describe the assessment strategies commonly used in learner-centered instruction?
8. Which areas would you like to know more about in terms of pedagogy and subject content knowledge for the professional development intervention? Why?
9. Is there anything else you would like to tell me about licensed science teachers' professional development needs?

Appendix 17: Focus group discussion guide after professional development intervention

1. Please share with me what you have learned from participating in the professional development intervention in terms of:

   i. Relevance to your pedagogical content knowledge needs
   ii. Quality of material in broadening your concepts on teaching students
   iii. Specific ways you think you have changed your classroom practice

2. How can you describe the professional learning community networking and sharing of materials/concepts between teachers from your schools in achieving the following:

   (i) Is networking helpful for subject content knowledge growth?
   (ii) Do you think this intervention has helped you to acquire pedagogical skills?

3. In what ways do you think you have benefited from professional development intervention in acquiring learner-centred teaching pedagogy?
4. What are the strengths of this professional learning intervention?
5. What are the weaknesses of this professional learning intervention programme?
6. Would you like this intervention to continue in your school? Why/why not?
7. What should be done in the future if the school-based professional development programme for licensed teachers is to be sustainable?

Appendix 18: Students' focus group discussion guide after professional development intervention

1. How would you describe this lesson taught today?
   - i. What do you think you have learnt in today's lesson?
   - ii. Did you enjoy it? Why?
2. Have you heard about learner-centred teaching methods?
   - i. Can you describe them?
   - ii. Do you like learner-centred teaching methods? Explain your answer
3. How would you describe the use of learner-centred instruction during the teaching and learning process?
4. How often have your teachers been using learner-centred teaching methods?
   - i. Are all teachers using learner-centred teaching methods?
5. What are the challenges of learning science subjects using learner-centred teaching methods?
6. Could you describe the advantages of learner-centred methods over teacher-centred teaching methods?
7. It is claimed in the literature that students do not like learner-centred teaching methods
   - i. Is this claim relevant? Explain
   - ii. It is claimed that Forms I and II students do not like learner-centred teaching methods. Is this claim relevant? Explain
8. Do you think English which is used as a medium of instruction is affecting your ability to learn your science subjects using learner-centred teaching methods? Explain
9. Is there anything further anyone would like to add, that you feel you've not had a chance to say?

Thank you very much attending and giving valuable feedback

Appendix 19: Information sheet for participants

Dear Participant

I am Vicent Naano Anney, Doctoral student at the University of Waikato, New Zealand. I am currently doing a research titled "Supporting Licensed Science Teachers Professional Development in Adopting Learner-Centred Teaching Pedagogy in Tanzanian Secondary Schools". The purpose of this project is to: identify and assess the professional learning needs of licensed science teachers; examine the strength and weaknesses of current professional development and evaluate the practices of licensed teachers in adopting learner-centred teaching strategies in the classrooms. Also, the study intends to develop and implement a professional development intervention for licensed science teachers in the selected schools to meet identified learning needs of these teachers. This study will be conducted over two years, from April, 2011 to April, 2013.

During this study, you will be asked to answer some questions on your professional learning needs, the strengths and weaknesses of the current professional development programmes, and classroom teaching practices in implementing learner-centred curriculum instruction. All the interviews, classroom observations and focus group discussion will be audio-taped. Please feel free to expand on the topic or talk about related ideas. Also, if there is any question you would rather not answer or that you do not feel comfortable answering, please say so and we will stop the interview or move on to the next question, whichever you prefer.

All the information collected will be kept confidential. I will keep the data in a secure place. Only I, the transcriber and the project supervisors will have access to this information. Upon completion of this project, all the data will be destroyed. Your identity will remain anonymous in the whole research process.

Appendix 20: Lesson narratives before professional development intervention

Narratives of Manimo's lesson

Lesson one: Algebra. Class: Form 1A (13-14years). Time: 8.00-9.20 am 08/07/2011

Manimo's first lesson was about algebra in mathematics and it was a 40-minute single period. During the tea time in an informal talk with Manimo, he said that he is unhappy and unenthusiastic about teaching mathematics because students do not like mathematics and science subjects in general. When we entered the classroom all the students stood up and greeted the teacher and the researcher. The class has 64 students and few desks compared with the number of students. Manimo introduced the researcher to the students, explaining he was doing PhD research on how to improve the teaching of science and mathematics. After the introduction, Manimo copied the title of the topic on to the blackboard and asked the students to open their exercise books ready for the lesson. This episode took almost three minutes and the class was noisy. Manimo did not revise the previous lesson and the objectives of the lesson were not provide or explained to the students. He did not have a lesson plan or lesson notes, and he used the mathematics textbook to extract questions. About three students were seen to have mathematics textbooks while the others depended on the questions on the blackboard. When calm was achieved Manimo copied four algebraic equations on to the blackboard: 1). $3n \times 5 = ?$. 2). $3n \times 5m = ?$ 3. ($4ax + 6a - 10az) \div 2a = ?$ 4. $\frac{2ab}{5} \div \frac{10a}{bc} = ?$

Manimo solved all the algebraic equations facing the blackboard and talking to it rather than facing the students and talking to them. The class was quite busy copying the solutions into their exercise books. Manimo used both English and Kiswahili to explain the algebraic concept without paying attention to whether the students were following. After solving each question he usually asked the whole class the general question "are we together?" to which the students responded in chorus, "yes". He then moved to the next question, until he had finished all the questions. During his movements in the classroom students copied what he wrote on the blackboard and there was no student-student interaction or teacher-student interaction.

Sometimes Manimo was fast in solving the questions and when he wiped the blackboard before some students had not finished copying them the students would say ‘please we have not finished!’ After finishing all four questions he then appointed two students to come on the blackboard to solve the following algebraic equation. $8ax \div 4 = ?$ The two students simultaneously solved it silently on the blackboard and after they had finished Manimo asked the class whole class “is the answer correct”? All students responded “yes”. The interesting observation is that the students did not talk while solving the equation, and also instead of one student solving one equation first, two students were solving the same equation at the same time, making it difficult for the students to follow the procedure on the blackboard. The students were too shy to speak and seemed to be afraid to be seen speaking to their friends. During the whole classroom session Manimo did not put any questions to his students except the two students who solved the equation on the blackboard. The teacher did not evaluate the lesson to see if it had been successful. Manimo left the students with homework, which consisted of only three questions: (1). $-3(m - 3p + q) = ?$ (2). $(bx + 4y - a)3 = ?$ 3. Divide $ab - ad + am$ by a. Manimo asked the students to solve the equations and hand in the exercise books for him to mark. Manimo didn’t give his students time to ask questions and he was not asked any questions by the students.

Narratives of Manimo’s lesson

Lesson Two: Current electricity. Class: Form II (14-15years). 11: 40am-1.00pm 08/07/2011

Manimo’s physics class was entitled ‘quantity of electricity’. The class was overcrowded with 108 students so that it was difficult for the teacher to move around the class to find out what students were doing at the back. Before teaching a new topic Manimo revised the last lesson and this exercise took almost 30 minutes, including solving the question about quantity of charge. The blackboard writing was haphazardly organized and he used small letters that were difficult to see from the back of the class, where some students were doing other activities while Manimo was teaching. Manimo asked students the ‘rapid fire questions where he didn’t give time for students to think and he also he spoke very fast during his teaching. Manimo asked four questions during his lesson, but he answered them all himself because he did not give students enough time to respond. Students’ involvement was very limited because he spoke to a few students at front of the class. A typical question might be “can you tell me what an electric charge is”. This illustrated that he used mainly teacher-centred teaching methods. While he was teaching, other students were looking through the window or talking to their friends. The lesson then stopped for five minutes while Manimo went out to talk with students outside to ask them to stop making a noise. He lacked classroom management skills. Manimo’s voice was very low and it was difficult for students to hear him, especially those with hearing difficulties or those sitting at the back in the overcrowded classroom. He gave the formula for electric charge Q= It. Then he elaborated on the relationship between electric current, time and charge. During the teaching, Manimo used both English and Kiswahili while emphasising points in his lesson and he had more difficulty conveying the lesson using English than Kiswahili. He failed to involve the whole class because he concentrated on one side of the class. He was unable to identify students who were lagging behind. During his teaching Manimo lectured the students and asked them ‘are we together’? The class would answer ‘yes sir’. He solved three examples on the blackboard and asked four questions that he answered himself. There was no pre-planned student assessment and learning activities such as homework. Also, the lesson was not summarised because he ran out of time as another teacher was waiting outside the classroom.

Narratives of Sungura's lesson

Lesson one: Elementary astronomy. Class: Form IV (15-16 years). Time: 12.15-1.35am

05/07/2011

Sungura's First lesson was Physics Form IV class. Physics for Form IV students is optional subject and so only 23 from among 67 students were registered to study physics. He didn't introduce the researcher as visitor to the classroom until the end of the lesson. Also, the interesting thing I observed is that Sungura asked the students studying physics to move to one side of the classroom and the rest to the other side. Due to the shortage of rooms, students studying physics and those who are not all sit in the same classroom while the physics teacher is teaching. As a result the noise from the non-physics students disturbed the lesson, because they would go out and start talking with other students outside the classroom, and it took almost four minutes for the class to be silent. Sungura did not have a lesson plan or teaching aid to support student learning. He did not have lesson notes and he used the physics textbook as his teaching notes. Immediately after the class had quietened down Sungura introduced the lesson by writing the topic on the blackboard, "introduction to elementary astronomy" and started teaching without explaining the lesson objectives or revising the previous lesson. He did not relate his lesson to students' prior knowledge. He started the lesson by saying "today I will introduce the concept called elementary astronomy, starting with a definition of the word, which comes from two Greek words, first 'astro' meaning star and 'nomy' meaning law! laws of! If you connect the two words then you get astronomy, therefore, the proper definition of astronomy is the study of the universe and the heavily bodies". Then he defined universe. "Universe can be explained as or can be defined as a space, which means an open space and everything in that space". Some students were not listening to what he is teaching and were doing a geography lesson. Sungura was just talking to the students as if he was addressing a public forum. He did not write the new concepts on the blackboard or even a definition of the concepts. The students were really confused because the lesson was very difficult to follow because the teacher was inconsistent and his English was inadequate, in particular his pronunciation of words. After talking for almost 30 minutes, Sungura then draw a circle to represent the solar system and tried to explain the concept of astronomy by putting the earth at the centre and in the circles he labelled some dots as planets. Then he discussed the concept of the solar system, which was even more confusing because the concept of the universe was unclear and then he introduced the geocentric theory. He concluded by discussing the occurrence of day and night. Sungura did not even ask any chorus questions to find out if the students were following and understood the lesson. He was unable to involve students in the teaching process. He lacked the necessary ability and skills to evoke students' prior knowledge and to use relevant examples by asking students what they see in the sky at night and in the afternoon. Sungura's understanding of both content knowledge and pedagogical knowledge was limited. When he was teaching he did not even have eye contact with his students. In his classroom practice Sungura did not display any elements of learner-centred teaching. After he had finished teaching he asked the class "does any student have a question". The students kept quiet for four minutes without asking any questions. Sungura then called one student by name and requested him to ask a question. The student asked 'what is the geocentric theory'? Sungura described it again. Then he read out two questions for the students' homework. 1. Explain the (a) occurrence of day and night (b) observation in the sky. Then we left the class. He hadn't prepared any students' activities in advance. Also, because the lesson was not pre-planned he covered too many concepts related to the topic. Typically, students' participation was more of listening and copying notes, and there was limited interaction between the students themselves and the teacher. Sungura typically demonstrated teacher-centred classrooms practices.

Narrative of Sungura's lesson

Lesson Two: Change of states. Class: Form III (15-16years). Time: 10:40am-11:20 am

06/07/2011

Sungura started the lesson by reminding students about the previous lesson, which was about the effect of temperature on the saturated vapour pressure of liquids. He revised the previous lesson by asking students to answer questions (1. what is saturated vapour pressure? 2. Who can explain how to determine saturated vapour pressure?). Unfortunately no student raised a hand to respond. Then after seeing that the students were not responding Sungura decided to answer the questions himself. After 10 minutes Sungura started teaching the new sub-topic of 'Humidity' by asking 'what is a hygrometer and what is its function'? No student raised a hand as the teacher spoke very fast, and he answered the question himself by writing the definition on the blackboard. Then he described dew point, relative humidity, and calibration of the hygrometer and wrote the summary on the blackboard. He also discussed the formation of dew point. The teacher used both Kiswahili and English to elaborate on the concepts, by explaining them first using English then followed by Kiswahili and sometimes using Kiswahili and English. The students were busy copying the drawings and notes into their exercise books from the blackboard. There was limited interaction between the students themselves and the teacher because the students were busy writing notes. Sungura's style of teaching was typically teacher-centred as he used the lecture method. The class had 63 students, which appeared to be too big for the teacher to manage. During the whole period Sungura asked his students three questions but they kept silent. No student had a textbook during the lesson. He was also not asked any questions by the students, despite requesting them to do so. During his teaching other students at the back were solving mathematics problems instead of studying physics. Sungura did not have a lesson plan and he used the textbook during the lesson as his teaching guide. The teacher copied notes for students from the physics textbook, which showed that he had not prepared lesson notes. He did not identify students' misconceptions about his lesson and he was unable to give relevant examples of relative humidity and why they were learning about it. The lesson was not evaluated. The lesson objectives were not identified in advance, probably because the teacher hadn't pre-planned any activities.

Narratives of Safari's lesson

Lesson One: Formula and bonding. Class: Form II (14-15years). Time: 8:00am-9: 20am

26/07/2011

Safari's class was overcrowded and there was no space to walk between the desks. The class had 101 students and there were insufficient desks and chairs for them. He was forced to combined three classes because of the shortage of teachers and classrooms in the school. Safari's lesson was about 'molecular formula' and 'empirical formula' and he started the lesson be revising the previous lesson with questions like what 'is valence' and how do you find the valence of various elements using different elements in the periodic table'. He used the concept of electronic configuration to determine the valence of an element. Safari explored different definitions of valence by asking three students to define it and then he asked the whole class to repeat verbally in chorus. He asked students to find the valence of oxygen, chlorine and sodium, and appointed students to come to the blackboard to show others how to find the valence of sodium. He asked the whole class if the answer was correct and then repeated the procedure. The revision of the lesson took almost 22 minutes. The classroom teaching was teacher directed or like a public rally with the students verbally repeating what the teacher thought important such as definitions. Safari didn't use any teaching aid to support his teaching. Then he introduced the sub-topic oxidation state/number, and ordered the students "I request you for your listen", after which he repeated his request in Swahili, "tafadahali mnisikilize sana". Then he said the "oxidation state/number is no different from the valence', and then he translated it into Kiswahili "haitofautiani sana na valence". Then he defined the oxidation number, and elaborated how to calculate the oxidation number using NaCl as an example of the formation of cation and anion, after which he asked his students "are we together?" Many students loudly replied "yes" and a few in a very low voice also said "No". Safari continued lecturing, mixing Kiswahili and English to emphasise his points. Then he demonstrated how to calculate the oxidation states of Beryllium, Oxygen and Chlorine. Safari was unaware of the importance of addressing misconceptions in science lessons because I became aware that some students confused the words ‘Ion and Iron’ because of how Safari pronounced these words. One student wrote ‘iron’ instead of ‘ion’. Also, safari wrote at the bottom of the blackboard, using small letters which made it difficult for students sitting at the back to read it. After teaching, Safari asked the students whether they had any questions. One student asked why hydrogen is mostly used for making acids. He answered the question in Kiswahili, which will make it difficult for students to answer this question in the examination because they will have to answer it in English. Safari used his old secondary teaching notes. There were no pre-planned learning activities relating to formative assessment. The lesson was not summarized or evaluated to see if the students had understood the lesson. During the whole period he asked four questions and was asked only one question by the students. The size of the class did not support learn-centred teaching methods and even for a qualified teacher it would be difficult to teach using learner-centred teaching methods in an overcrowded classroom as Safari had to do.

Narratives of Safari’s lesson

Lesson Two: Coordination and irritability. Class: Form III (15-16years). Time 12.15-1.35pm

27/07/2011

Safari started the lesson by revising the previous lesson. The class was too big for him to manage. It had 94 students with three streams (Form 3 A, B, and C) because of the teacher shortage. He started by revising the previous lesson and asking students questions, but no-one raised hand to respond. Because the students had not voluntarily responded he called them by name to respond to his questions. One student defined the concept of coordination, which Safari re-emphasized by repeating the student’s definition. Safari mixed English and Kiswahili during the lesson, particularly when reinforcing important points. Safari used the rapid fire style of asking questions, not giving students enough time to answer, and so the students remained silent. He listed the components of coordination (neurons) on the blackboard and asked the students to read out together what he had copied on to the blackboard. Safari's writing was difficult to see at the back because he had written at the bottom of the blackboard with the result that some students were standing while writing. Safari hadn't prepared any notes, but he copied notes for students from the biology textbook. The lesson was not summarised and there was no formative evaluation to determine whether the lesson had been successful. Apart from copying notes on to the blackboard no student activities were given during the lesson. Safari used the whole class instruction method.

Narratives of Qwary's lesson

Lesson Three: Changes of states in the refrigerators. Class: Form III (15-16years). Time: 12.15-1.35pm

18/07/2011

Qwary's class consisted of 63 students. It was difficult for him to move around the class to see what students were doing at the back. Before teaching the new topic Qwary revised the last lesson. He copied a question on the blackboard (Calculate the heat required to change the water of mass 20kg at 20^{o} centigrade into steam if the specific heat capacity of water is 2.26×10^{3}J/k) and pointed to one student to come to the front of the class to do the calculation. She did this silently, neither explaining the procedure nor involving other students. Qwary then repeated the question for the whole class. While teaching Qwary faced and talked to the blackboard rather than facing students. The question was a repetition of the previous lesson because I saw some students looking at their exercise books when the student was doing the calculation on the blackboard. This revision episode took almost 20 minutes. Qwary used both Kiswahili and English to emphasise lesson concepts. He then started teaching his lesson by asking the students 'what is a refrigerator'. No students rose up his hand to respond to this question. Teacher answered the question by describing what refrigerator do, and then drew a diagram of a refrigerator on the blackboard showing its parts. Instead of asking students to label these parts he did so himself. Student-teacher interactions were limited with the teacher done all the teaching while the students listened and copied notes into their exercise books. Qwary hadn't prepared any teaching aids and pre-planned student activity. Qwary explained how different parts of the refrigerator work by writing summary on the blackboard how these parts work. After every finishing summary of each section Qwary asked the class "are we together"? students responded "yes". Qwary's knowledge of the subject was limited and his inability to teach in English was also inadequate. He was forced to explain concepts in Kiswahili. After he had finished labelling the refrigerator he wrote notes in the blackboard, which the students copied into their exercise books. Qwary hadn't indicated the title of the subject matter in his notes. Qwary had copied his notes from the physics textbook. Also some students at the back were doing other activities while Qwary was teaching physics and asked only one question during his lesson and he was not asked any by students. The lesson at the end was not summarized and there was no evaluation to see if the students had understood the lesson.

Narratives of Qwary's lesson

Lesson Two: Excretion in human. Class: Form III (15-16years), 8.00-9.20 am 17/07/2011

Qwary's biology lesson was about excretion in humans. The class had 67 students. Before teaching the new lesson Qwary revised the last lesson. He defined what excretion is and why it is important to study the excretion of living organisms. Qwary asked the students to repeat the definition of excretion. One student defined excretion and then Qwary asked the whole class, "was it correct" to which the students responded 'yes'. Then Qwary moved on to the new lesson by listing the excretion organs such as skin, the kidneys, the bladder, the lungs and the urethra. He did not inform the students of the objectives of the lesson or the learning outcome at the end of the lesson. Qwary described the excretion process in the kidney by drawing and labelling a human kidney (Glomerulus, Bowman's capsule, Nephrons, Henle's loop, ureters, urinary bladder etc.) which took almost 15 minutes of the teaching time. During this time he outlined the process of excretion in the kidney and the product of the excretion. After labelling each part he asked the whole class to read it loudly. The lesson engaged students very little, particularly in labelling the diagram. Qwary did not finish discussing the excretion process in the kidney because most of the teaching time was used to draw the diagram, as another teacher knocked at the door telling Qwary that the period was over. Qwary left the class and told the students that he would continue next time. Qwary mixed English and Kiswahili during the lesson. I noticed that three students had biology textbooks, which they used to draw the kidney while the teacher was drawing it on the blackboard. Qwary used the biology textbook from which to extract his notes for teaching. He didn't have a lesson plan or lesson notes and hadn't pre-planned any student activities. He was also less skilled in using formative assessment techniques. The lesson was more teacher-centred as Qwary didn't involve students in labelling of the diagram. It seemed too difficult to use learner-centred teaching methods because the class was large.

Narratives of Qwary's lesson

Lesson One: Chemical kinetics and equilibrium. Class: Form III (15-16years). Time: 9.20-11.40 am

11/07/2011

Qwary's chemistry lesson was about chemical kinetics and equilibrium. The class had 71 students and was big and difficult to manage, because the desks were arranged in the traditional teacher-centred setting. On entering the classroom the students stood up and greeted us and then Qwary asked them to sit down and introduced the researcher. After the introduction Qwary asked the students to open their exercise books and immediately started teaching the new sub-topic 'factors affecting rate of chemical reaction'. Qwary didn't explain in advance the lesson objectives and student learning outcome after the lesson. Qwary listed the factors affecting the rate of chemical reaction, which include concentration, temperature, surface area, light and catalyst. Qwary started by describing how concentration of reactants affect the rate of reaction using a chemical equation ($Na_2S_2O_3$ + HCl), which he wrote on the blackboard. He described the concept using a graph to show what will be the rate of reaction when concentration increases. The teacher explained to the students that the rate of reaction is directly proportional to concentration. He asked the students why the rate of reaction increases when the concentration of a chemical substance increases. This proved to be difficult question for students as many started looking down instead of looking to the teacher to respond to the question. The teacher pointed to two students to answer the question but neither was able to give the answer, and so he answered it himself. He explained that when concentration is high the rate of collision of particles also increases. The teacher himself struggled to describe the concept by reading the textbook to describe the rate of chemical reaction. During the teaching Qwary copied a short summary while students silently wrote it in their textbooks. The teacher only managed to cover one of the four factors he outlined at the start of the lesson. He was asked by a student ‘how do you know those particles are colliding fast? He had a difficult time answering this question and he told them he would discuss it explain it next time. The lesson was not summarized or evaluated to see whether or not students had understood it. The teacher asked three questions during the lesson and was asked only one question. The lesson was generally teacher–centred and the teacher appeared to have limited content knowledge for describing the rate of chemical reactions.

Narratives of Tiita’s lesson

Lesson One: Archimedes principle. Class: Form II (14-15 years). Time: 10.20-11.40 am

13/07/2011

Tiita started the teaching session by revising the previous lesson and involved individual students by identified them by name and they were very cooperative. Teacher encouraged the students who responded to the questions by asking the class to applaud or he would say ‘excellent’ to correct answers. He also re-emphasised students’ responses by repeating the correct answer and why the response was correct. After revising the previous lesson Tiita introduced the new lesson by outlining its objectives on the blackboard. Then he defined the concept of ‘upthrust’ and ‘relative density’ and then copied these definitions on the blackboard. Tiita had a lesson plan and notes for his students in his exercise book and he also had a physics textbook. He began by asking students about their understanding of upthrust and weight and students to differentiate them. They answered in Kiswahili and Tiita re-emphasized it again using Kiswahili. This practice helped the students to understand the focus of the lesson. Then he wrote a question (A stone weighing 1.2N in air and 0.8 N when totally immersed in mercury of density 0.008kg/m$^{3.}$), on the blackboard for students to calculate the: i) upthrust ii) weight of mercury displaced iii) mass of mercury displaced iv) volume of mercury displaced v) density of the stone vi) relative density. Students in each row were asked to solve the question in pairs while he walked around to see what students were doing. After ten minutes each group was asked one to write their answer on the blackboard, which they did and were rewarded for their work. Tiita then summarised the lesson. Tiita's lesson had elements of learner-centred instruction. Tiita closed the lesson by defining upthrust, density and relative density, but hadn't prepared a take-home assignment for the students. Generally Tiita's lesson was interactive though it included whole class instruction activities because of the large number of students in the classroom.

Narratives of Tiita's lesson

Lesson Two: Chemical equation. Class: Form II (14-15 years). Time: 8.00-9. 20 am

12/07/2011

Tiita's chemistry lesson started after morning tea break when the students usually take more time drinking porridge, which took up a few minutes of his teaching time. He spent five minutes waiting for the late students coming from the morning tea break. Tiita's chemistry class consisted of 63 students. Tiita introduced the researcher to the class then he asked his students to open their exercise books. He revised the previous lesson by copying three chemical equations on to the blackboard and asked the students to solve them on the blackboard, which they managed to do, and then Tiita repeated the concept. After finishing his revision he started a new the lesson on ionic equations. The teacher first discussed the rules of writing ionic equations and then demonstrated how to drop the spectator ion in order to write the ionic equation. Thereafter he copied two equations on the blackboard and asked the students in groups of three to write an ionic equation using the equation he had written on the blackboard. The formation of groups was difficult because there was not enough space because the class had many students and it became noisy. Though it was difficult, the teacher went round to see what students were doing. After ten minutes of students' discussions Tiita appointed two students to come to the blackboard to show how to write an ionic equation from their group's answers. Two students did this silently without explaining how they did it and then Tiita asked the whole class if they are correct. The students answered 'yes' in chorus. Tiita tried to engage students in the learning process and allowed two students to work on the black board at the same time. Teacher then wrote up lesson notes for students on the blackboard for almost 12 minutes while students silently copied the lesson summary. Tiita closed his lesson without summarising or evaluating it. Generally Tiita's lesson was interactive although not leaner-centred instruction. The lesson was whole class instruction with little opportunity to develop individual skills, and the teacher had not prepared a take-home assignment for the students that could help develop their metacognition skills.

Narrative of Pombe's lesson

Lesson One: Human digestive system. Class: Form II (14-15 years). Time: 1.00-2.20 pm

07/07/2011

Pombe's lesson was about the digestive system in humans. As soon as we entered the classroom Pombe asked the students to open their exercise books and did not revise the previous lesson. She did not have a lesson plan or notes for the students instead used textbooks for her teaching notes. Rather than involving the students in identifying the enzymes responsible for digestion in the mouth and oesophagus, Pombe listed them herself and described them one after another. She described the digestion process in the mouth, oesophagus and ileum. Each time she finished explaining the concept she asked the students "have you understood?" to which they replied "yes madam". During her lesson Pombe spoke very fast and could ask more than two questions a minute, without waiting for a response to the first question. This style of questioning appeared to confuse the students as they become passive during the lesson. Pombe was the source of all knowledge during the lesson. She had a lot of difficulty describing some biology terms and the function of enzymes used during digestion such sucrose, sucrase, amylase glucose, lipase, Renin and trypsin. Pombe did not deal with students' misconceptions because one student mentioned that water was an enzyme and she didn't correct this. Instead she asked the whole class whether water was an enzyme, to which many students chorused "no" and a few said "yes". Pombe didn't use her teaching aid at the beginning of the lesson, but almost at the end then she displayed the hand drawn diagram of the mouth and oesophagus section of the digestive system. Her writing was very small and difficult to read by the students sitting at the back of the class. The lesson was not summarised, she asked only four questions during her lesson and she was not asked any by the students. No homework was given for students to evaluate student learning.

Narratives of Pombe's lesson

Lesson Two: Digestion in the ileum. Class: Form II (14-15 years). Time 10.00-10.40am

8/07/2011

Pombe's second lesson was a continuation of her previous lesson about the human digestive system, and focused on the digestive system in the ileum. She started the lesson by reminding the students about previous the lesson on the digestion process in the mouth and oesophagus by mentioning important enzymes in the month. Pombe described the function of lipase, amylase and ptyalin as digestive enzymes in the month. The revision took almost 13 minutes of teaching time. She then moved on to the new lesson by describing the function of ileum as part of the digestive system. Pombe did not have an outline of the lesson objectives but went directly to the new lesson. She drew a diagram of the ileum on the blackboard labelling the parts and describing the function of each part in the process of digestion. The students busily copied the notes that Pombe wrote on the blackboard. She explained that the ileum secretes hormones such as gastrin, secretin, protease and carbohydrase and the final product is protein and carbohydrate. This lesson was a more organised teacher-centred lesson because Pombe used notes she had prepared on a piece of paper unlike the previous one when she used the textbook. Pombe's teaching was typically teacher-centred because the students were not involved the lesson. She started the lesson by revising the previous lesson and then moved on to the new lesson, during which time the role of students was that of listening. She did not utilize students' prior knowledge as a basis for their understanding. Pombe spent 15 minutes of teaching time copying notes on the blackboard. The lesson was not summarised or evaluated to see if the students had understood it. While going out after the session I asked her why she hadn't evaluated the lesson. She replied that she would use the monthly test to see if they had read the topic. Pombe hardly used formative assessment strategies during her teaching.