MSc Programme Educational Science & Technology
Curriculum & Instruction

Exploring the practical use of ICT tools by teachers for making supplemental teaching/learning materials in secondary schools in Tanzania

as an effort of supporting student learning in science and mathematics

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Preface

I went to Tanzania for the first time as a secondary school teacher in 1992. The school was located in a rural town where there was no electricity at the time. The night was black. But students were studying even night in classroom or in dormitory using kerosene lamp. I really admired their effort and enthusiasm for studying. The life was not easy for me, but I could go through it because people helped me. Since that time I have met many Tanzanian; teachers, students, ministry officials and people in the surroundings like cheerful young guys, sturdy farmers, lovely kids and powerful ladies. They always helped me when I was in trouble and cheered me up. It was all the same in this study.

An explorative research like this one is very interesting because there are a variety of encounters with unknown situations, but also very challenging in that it has to deal with a number of uncertainties without having an established framework of the study at least when it started. Moreover conducting a research in schools is not an easy task. It is true especially when the researcher is a foreigner. I am deeply indebted to many people for their kind support and cooperation during the research. It was not possible for me to carry out the field study without their kindly understanding, assistance, support and generosity.

Although it is not possible to mention all the people for my appreciation, I would like to express my gratitude to some of them. I would like to thank Dr. Nesta Sekwao for her help to obtain the Ministry's permission for the research, Elia Kibga for his advice in selecting schools, Dorothy Mwaluko for her kindly advice on the research activities, and Dr. Frank Tilya for supporting the research as a local advisor from the beginning of the study. I also want to thank the then principal of Dar es Salaam Teachers' Training College and the head teachers of two secondary schools for allowing me to conduct the research at the schools and for their kindly support. I am grateful to Simon Shayo for his assistance during the research in Dar es Salaam, and to Micheal Mnjokava and Gloria Kang'oma for their insightful advice to the study. Through the experiences of working with teachers, I had precious experiences and learnt many things. I am really thankful to the participant teachers as well as other teachers for their positive participation and contribution to the study. And I would like to express my appreciation to the students who took part in the research. It is my hope that this exploratory study would make a contribution towards the effort to improve student learning in science and mathematics in secondary schools in Tanzania.

I lived in African countries for several years, but studying abroad was the first experience for me. I was really lucky to have nice friends in the University of Twente, especially kind and energetic Dutch and Belgian classmates and a variety of international students. This one year was not short for me having many challenges, but I could survive till the end because I was inspired by their friendship and casual talk. I could have a variety of experiences shared with them. Particularly I am grateful to two African friends, John Menoe for sharing the student life during this one year, and Fidelis Mafumiko for keeping reminded me the life in Tanzania through Kiswahili conversation. *Dank u wel*, *Thank you very much* and *Ahsante sana*.

I am grateful to the management staff of the master programme, especially Dionysia Loman, Frances Leusink and Jan Nelissen who provided international students with support, help and encouragement including some surprises. I am also thankful to the tutors of the master programme for teaching and giving us tasks through which I could learn many things. I found myself fortunate to have teachers, Dr. Annette Thijs, the second assessor for my final project, is

one of them, who have a profound experiences, knowledge and insights in the field of education in sub-Saharan African countries.

Finally I would like to express my sincere appreciation to my supervisor Dr. Joke Voogt who coached and guided me through the study. Writing a thesis in English was a challenge to me. I greatly appreciate her sharp and constructive guidance (sometimes it was destructive in that I had to completely reconsider my immature staff.) for this thesis. I am really thankful for her generous and enthusiastic support of guiding, reading, correcting and giving feedback on my work.

Masahiko Sugiyama
Enschede, September 2005

Summary

Background

Poor performance in mathematics and science subjects has long been a controversial issue in secondary education in Tanzania. In order to find a way to support student learning in science and mathematics, the study was aimed to explore the practical use of ICT by secondary school teachers for making supplemental teaching/learning materials in secondary schools in Tanzania.

The study consists of mainly two parts. As the first part, the literature was reviewed to build a theoretical and empirical base for the study. As the second part of the study a field research was conducted in May and June 2005 at two secondary schools in Tanzania.

Literature review

In the literature review, a preliminary problem analysis was attempted to find out the problems attributed to the students' poor performance in science and mathematics focusing on sub-Saharan African countries such as Tanzania. From the problem analysis, three key notions: *motivation*, *visualization* and *language support*, appeared to be relevant for the study, particularly in the design of supplemental teaching/learning materials to challenge the problem of poor performance in science and mathematics. The literature was reviewed to learn, from some theories and empirical study findings, how the three key words can be applied in the study. The literature was also studied to gain insights into the practical approach of an in-service teacher training to promote ICT use in secondary schools.

Field research – context analysis

The field research was composed of main three components. Firstly a context analysis was carried out to collect information about: (i) students' problems in mathematics and science at the secondary schools in order to obtain guidance as to what supplemental teaching/learning materials should be developed in the study, (ii) the current situation of ICT use at the schools and amongst secondary school teachers, and (iii) teachers' practice of making supplemental teaching/learning materials. From the context analysis, a number of things were found.

- A number of students of the two participating secondary schools did not understand the basic arithmetic operations and made mistakes in the basic calculations. It was also found that students, especially the lower grades, had difficulty in learning science (biology) because of the language of instruction in secondary schools that is English. These results indicated that there was necessity in secondary schools to give special support for those students who did not understand the basic concepts in science and mathematics. A remedial measure was to be taken to improve student learning in secondary schools.
- Although many teachers at the two participating schools still had limited experience and skills in using ICT such as computer and the Internet, there were some teachers who used the ICT regularly. It was also found that teachers made the handouts with handwriting, and for duplicating materials they often made copies using photocopy machines.
- Mainly three conditions were perceived by teachers as major constraints which hinder teachers' practice of using ICT for making supplemental teaching/learning materials in the schools. They are (i) poor printing condition in the school, (ii) administrative procedure for using ICT and for printing materials and (iii) problems pertaining teachers themselves such as lack of skills, motivation and creativity. As for the administrative issue, the headmasters had different opinions from teachers, and they emphasized the necessity of administrative control over printing procedure. They also showed a great concern about the security for computers in the school.

Field research – material development

As the second part of the field research, supplemental teaching/learning materials were designed and developed based on the findings in the literature review (i.e. the three design features: *motivational design*, *visual representation* and *language support*) as well as on the results of the context analysis in the field research. Although the impact and effectiveness of the materials were not systematically evaluated in the research, informal evaluations were made by observing students' reactions for the materials and by interviews with teachers and subject experts. It was indicated that the material designs and contents were appreciated by students as well as teachers and subject experts.

Field research – ICT training

ICT training was conducted for selected science and mathematics teachers at the two schools as the third component of the filed research. In addition to the aim of contributing to increase teachers' confidence and skill in using ICT tools, it was aimed to observe, through the training programme, how ICT tools such as computer and the Internet could be used by secondary school teachers to make supplemental teaching/learning materials in the real school settings. It was also aimed to raise their awareness of practical use of ICT for making supplemental teaching/learning materials to support student learning in secondary schools. The training programme was designed based on the findings in the literature review, and an activity guide was developed by the researcher as an instructional material for the training. The main focus of the training was to promote practical use of word processing programme, especially for drawing diagrams and making use of digital images to create supplemental teaching/learning materials. From the training activities, it was found that participant teachers learnt the basic techniques quickly and enjoyed the training tasks, especially the practice of drawing and using digital images.

Conclusions and recommendations

In this study, it was found that, though most of secondary school teachers had still rather limited experience and skills in using ICT tools, if the facilities were available and if teachers had some experience of using computers, it was not so difficult for teachers to make use of ICT tools such as computers and the Internet. However, when it comes to making supplemental teaching/learning materials in the real school settings, other situational conditions become an obstacle for the practice. One of the problems was the condition of printing in school to duplicate the materials. Another constraint was limited availability and accessibility to the ICT tools in schools when teachers want to use the tools. These problems need to be solved physically, financially and also administratively in the school. In addition, in order to promote teachers' practice of using ICT tools for making supplemental materials, ICT training is required to enhance not only teachers' ICT skills but also their pedagogical knowledge and ideas for creating the teaching/learning materials to support student learning.

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Chapter 1

Introduction

This introductory chapter presents the background of the study which was aimed to explore the practical use of ICT tools by teachers to make supplemental teaching/learning material as a way of supporting student learning in science and mathematics in secondary schools in Tanzania. Firstly the original motives and two assumptions made in the study are described in section 1.1. In section 1.2 the aim, research questions and the research approach adopted in the study are described. Section 1.3 presents the significance and limitation of the study, and the chapter ends with section 1.4 giving an overview of the structure of the thesis.

1.1 Background of the study

1.1.1 Problem - students' poor performance in science & mathematics

Since independence African countries have been striving to improve quality of mathematics and science education as it is viewed as one of the important key elements of economical development. However, their endeavours seem not to have been very successful to improve students' performance in mathematics and science subjects[1] in most of the African countries (e.g. de Feiter, Vonk & van den Akker, 1995; Gray, 1999).

Although students' academic performance can be measured with a variety of indicators, one of the commonly used indices is the result of standardized achievement tests such as the national examinations set by a formal institute inside or outside the country, and poor performance in the national examinations in mathematics and science subjects as long been a controversial issue in secondary education in Tanzania (Chonjo, Osaki, Possi & Mrutu, 1996; Kitta, 2004; O-saki, 2004a; Sekwao, 1986; Tilya & Voogt, 2002).

According to the National Examinations Council of Tanzania (NECTA), in the Form 4 National Examination (CSEE) for the years 1995-2002, the average overall "*failure rate*" in Basic Mathematics which is a compulsory subject in the O-level secondary education in Tanzania was more than 70 % (Mazigo, 2003). It is often claimed that there are students who do not understand basic concepts in mathematics and science in secondary schools. For example, it was found in Tanzania that a significant number of students in O-level secondary schools did not understand basic arithmetic operations and made mistakes such as 0 - 5 = 0 or - 9 - 3 = - 6 (Sugiyama, 2003). The problem dooms to be worse, when looked at the current political trend for rapid expansion of secondary education sector in sub-Saharan African countries, which may cause other adverse conditions such as increasing class size and further shortage of secondary school teachers. In order to improve students' performance in mathematics and science subjects, it is of great importance to find a number of practical ways to cope with the problem.

This study was originally motivated to find a way to improve students' understanding of basic mathematics and scientific concepts such as arithmetic operations amongst lower grade students in secondary schools in Tanzania.

[1] In this study, science subjects include conventional science subjects: physics, chemistry and biology.

1.1.2 ICT in secondary schools

Information Communication Technology (ICT) is now regarded to have promising features to enhance and support teaching learning practice in schools (e.g. Cox, Webb, Abbott, Blakeley, Beauchamp, & Rhodes, 2004; McFarlane & Sakellariou, 2002; Osborne & Hennessy, 2003; Voogt, 2003). There are also efforts made to explore the use of ICT on purpose to support student learning and improve their performance in secondary schools in African countries (e.g. Kozma, McGhee, Quellmalz, & Zalles, 2004; Tilya, 2003;).

As in other countries, computers are now gradually spreading into secondary schools in Tanzania, and in large cities it is not rare to see a computer(s) in secondary schools. The Tanzanian government is also encouraging schools to implement ICT and introduce ICT education in the curriculum (MoCT, 2003). There is little doubt that ICT is now regarded as a promising educational tool which may bring about new innovative practices in schools. Although at present the use of ICT in schools is still rather limited in most of the secondary schools in Tanzania, people are interested in ICT and eager to take advantage of the technology.

In order to promote ICT implementation in schools, it is significant to facilitate teachers' practice of using ICT in such a way that they can find relevance and usefulness of ICT in real school settings for themselves. The exploration of practical use of ICT by secondary school teachers in an effort to improve students' performance in Tanzania is the other interest of this study.

1.2 About the study

1.2.1 Two assumptions

At the start of this study, two assumptions were made by the researcher to challenge the problem described above. The two assumptions are:

- If teachers can create supplemental teaching/learning materials, it will be of great help to support student learning in secondary schools in Tanzania.
- Information and Communication Technology (ICT) could play a role to facilitate teachers' practice of making supplemental teaching/learning materials in schools.

In this study ***supplemental teaching/learning materials*** are meant to be print-based materials such as handouts, worksheets and drill-exercise sheets. The materials are aimed to support student learning by supplementing the conventional textbooks and also providing a learner friendly explanation to promote students' understanding of basic scientific concepts particularly amongst lower grade secondary school students in Tanzania.

1.2.2 Aim of the study and research questions

This study consists of mainly two parts. Firstly, in order to find tentative validations of the two assumptions, empirical and theoretical rationales were sought in the literature. As the second part of the study, a field research was conducted in Tanzania to explore validity and practicality of the assumptions in real context of the study.

The research question which guided the research was:

> ***How can ICT tools facilitate teachers' practice of making supplemental teaching/ learning materials in secondary schools in Tanzania?***

The following sub-questions were formulated to elaborate the main research question.

- *What materials may have relevance to support student learning in secondary schools in Tanzania?*
- *What ICT skills or experience do Tanzanian secondary school teachers have at present?*
- *How can teachers make use of ICT to develop teaching/learning materials?*
- *How do Tanzanian teachers perceive the use of ICT for preparation of teaching/learning materials?*
- *What materials may practically be developed by teachers using ICT in secondary schools in Tanzania?*

The main focus of the study was placed on the exploration of teachers' use of ICT to create teaching/leaning materials with major concern on "***validity*** and ***practicality***" (Nieveen, 1999) of the practice. It should be noted that the impact and effectiveness of the materials were not substantially explored in the study.

1.2.3 Research approach

The research was aimed to explore practical use of ICT tools by Tanzanian secondary school teachers to make supplemental teaching/learning materials in schools. Teachers' use of ICT and their practice of creating teaching/learning materials largely depend on teachers' skill and experience of ICT use, and their awareness and motivation to make materials. Because these practices are in general not common at present in Tanzanian secondary schools, in this study the researcher needed to make a certain intervention to facilitate the intended practices (i.e. use of ICT tools for material creations). It was also aimed, through the research practice, to contribute to increase teachers' confidence and skill in using ICT tools (i.e. ***mutual benefits***) and to raise their awareness of practical use of supplemental teaching/learning materials to support student learning in secondary schools.

The research approach applied in the study is characterized as ***development research*** which aims at (i) supporting prototypical material development, and (ii) generating methodological directions for the design and evaluation of the materials (van den Akker, 1999), though, due to the explorative nature of the study as well as time limitation, the evaluation of effectiveness of materials and its design approach were not substantially pursued in the study.

Under the concept of ***development research***, the field research was conducted at two secondary schools as an ***exploratory case study*** (Yin, 2002) aiming at a closer observation of the school environment and deeper interactions with participant teachers. As an operational definition of the case study method, Yin (2002) states that a case study is "*an empirical study which investigate a contemporary phenomenon within its real life context*", especially when the contextual conditions are highly related to the phenomenon of the study (p.13). As for the research strategy, it is suggested that data should be collected from multiple sources of evidence to achieve a triangulation of evidence and that research procedures need to be well documented to add to the ***reliability*** of the study. These conditions of case studies were taken into account in the research design of this study.

The field research was carried out to observe the present situation of ICT use amongst secondary school teachers and also to explore significance as well as practicality of using ICT tools for making supplemental teaching/learning materials in real school settings.

In the field research, the two schools were purposefully selected to have appropriate conditions for the study, which included the presence of (i) some computers available in schools, (ii) science and mathematics teachers who have interest in the study, and (iii) understanding and

cooperation of school administration. In the selection of the schools, the researcher referred to recommendations from ministry officials. He asked the permission for the field research from the Ministry of Education and Culture, the Teachers' Training College to which one secondary school belongs, and the heads of two secondary schools.

1.3 Significance and limitation of the study

1.3.1 Exploration of practical use of ICT in school in African countries

The research is aimed at exploring a way to promote practical use of ICT tools by teachers in secondary school in Tanzania. It is expected that the findings and insights gained in this study will contribute to add to empirical knowledge for the further exploration of practical use of ICT in education, especially in developing countries, by giving an in-depth description of the current situation of ICT use in real school settings in Tanzania as an example of sub-Saharan African countries, and also by generating an idea of a feasible intervention to promote teachers' use of ICT in schools in similar settings.

1.3.2 Contribution to teacher professional development

In sub-Saharan African countries, several intervention researches have been conducted to enhance teacher professional development in a number of in-service projects (e.g. Kitta, 2004; McKenney, 1999; Motswiri, 2004; Ottevanger, 2001; Stronkhorst, 2002; Thijs, 1999; Tilya, 2003). These studies show the significant role of "*exemplary curriculum material*" in in-service intervention which aims to promote innovative teaching approaches in secondary schools. It is also argued that teachers can improve their subject knowledge and teaching skills through the practice of creating "*classroom materials*" (McKenney, 2003). Although the materials developed in this study were not "*exemplary curriculum materials*" as meant in the above researches, yet it was expected that teachers might improve their subject matter knowledge as well as pedagogical skills through the process of considering how to create and make use of supplemental teaching/learning materials by themselves.

1.3.3 Exploration of practical approach to support student learning

As previously mentioned, the study did not aim to find out the effectiveness and impact of supplemental teaching/learning materials on actual student learning. However it was expected that the research might be able to provide tentative rationales for using supplemental teaching/learning materials to support student learning as one of the practical approaches to alleviate the problem of students' poor performance in science and mathematics which is a common problem in sub-Saharan African countries.

1.3.4 Limitation of the study

As is the common problem in any field research, the limitation of time was one of the constraints in this study. Despite of the researcher's cautious efforts, it might have caused a superficial understanding of some aspects of the phenomena in the cases. Due to the time constraints, the field research was conducted at only two secondary schools in Tanzania. The schools were chosen in a rather selective manner to have appropriate conditions for the research. This limited number of the research places and its selectiveness is likely to affect the generalization of the outcomes of this study. Therefore in order to increase the "external

validity" (Yin, 2002) by "analytical generalization" (ibid), this thesis attempts to give detailed descriptions for the context of the research and the research procedures (i.e. "thick description of the process-in-context" as described by van den Akker, 1999), and also to provide discussion based on theoretical and empirical study findings in the literature as much as possible, so that future studies can benefit from this study.

1.4 Overview of the thesis

The following chapters present the finding and results of the study which consists of the part 1: literature-based study and the part 2: the field research conducted in April and May 2005 in the United Republic of Tanzania.

Chapter 2 and 3 give the outcome of the part 1 which are more theoretical part of the study. ***Chapter 2*** describes contextual situations of the study. It illustrates some aspects of Tanzania, including general information, the education system and the language issue. ***Chapter 3*** presents a summary of the findings and insights gained in the literature review. Firstly a preliminary analysis on the problem of student poor performance in science is described, which followed by brief discussions on three important key notions in this study: *motivation*, *visual representation* and *language support*. The third part of the literature review focus on ICT training as an endeavour of teacher professional development in sub-Saharan African countries. Theoretical and empirical insights into development and implementation of in-service training programme were sought in the literature.

Chapter 4, 5 and 6 describe the results and finding of the field research as the second part of the study. ***Chapter 4*** presents the results of **context analysis** which involves a Mathematic test, a Biology test, a Student Questionnaire, a Teacher Questionnaire and semi-structured interview with head teachers. ***Chapter 5*** describes an attempt to design and develop prototypical **supplemental teaching/learning materials**. The original intention and its real practice of material development are discussed. ***Chapter 6*** reports the **ICT training** conducted at two secondary schools. Observed teachers' skills, practice and their perception towards the use of ICT tools are described. Finally a summary and conclusions of the study, and recommendations for further research are addressed in ***Chapter 7***.

Chapter 2

The context of the study

In any research, in-depth understanding of contextual situation of the study is of great importance. This chapter presents the context of the study aiming to understand background information of the United Republic of Tanzania, in which the field research was conducted. Firstly ***general information*** *of the country, geography, history and socio-economic situation are briefly described in section 2.1. Section 2.2 gives an overview of the* ***education system*** *of the country. Section 2.3 illustrates some of the* ***policy issues*** *in the secondary education of Tanzania. Section 2.4 describes the* ***language issue*** *which is a complex and sensitive topic in the secondary education in Tanzania. In section 2.5 the government policy of* ***ICT*** *and its implementation in secondary schools are described. Chapter ends with a summary in section 2.6 giving some implications gained in the chapter.*

2.1 The United Republic of Tanzania

2.1.1 Geography

The United Republic of Tanzania is an east African country located near the equator having the coast of the Indian Ocean. Tanzania consists of the mainland part formerly called Tanganyika and islands including three major ones, Zanzibar, Pemba and Mafia. The total area of the country is 945,087 square km. The country shares its borders with eight neighbouring countries: with Kenya and Uganda at the northern part, with Rwanda, Burundi and the Democratic Republic Congo at the west, with Zambia and Malawi at the southwest part and with Mozambique at the southern part.

Figure 2. 1: Map of Tanzania

Source: *http://www.tanzania-web.com/home2.htm*

The *Great Rift Valley* runs through the country from the north to the south, and the Africa's largest lake: *Lake Victoria* and the Africa's deepest lake: *Lake Tanganyika* border the eastern and the northern part of the country. Mount Kilimanjaro, the highest point in the African continent, is also located in Tanzania.

2.1.2 History

Although little is know of the history of Tanganyika's interior part during the early centuries of A.D., the coastal area had contacts with other civilizations as early as the 8th century when Arab traders arrived. When the Portuguese arrived at the end of the 15th century, highly developed towns had already been established along the east African coast. Swahili civilization (from the Arabic word "swahili" which means "coast") grew up in the coast areas and Swahili language developed from the mixture of African Bantu language and Arabic vocabulary.

European exploration of the interior began in the middle of 19th century. As the scramble for African territory amongst the European countries escalated in the 1880s, Germany took over direct administration of Tanganyika in 1891. During the period of German colony Kiswahili was used as a "language of government administration" and also as the medium of instruction in schools (Kurtz, 1972, quoted in Brock-Utne & Holmarsdottir, 2004, p.68). After World War I, the German territory was mandated to the United Kingdom through the League of Nations. During the British colonial period (1918-1961) English was used as the official language as well as the language of instruction through the whole education system (Rubagumya, 1991). Tanganyika gained her independence from the United Kingdom in 1961. In 1963 Zanzibar, which had been a British protectorate, won its independence. The United Republic of Tanzania was born in April 1964 when Tanganyika and Zanzibar formed a union.

In 1967, the first president of Tanzania, Julius Nyerere issued the Arusha Declaration, a major policy statement that called for "egalitarianism, socialism, and self-reliance". Under the policy, the factories and plantations were nationalized and rural development programme called *ujamaa* was promoted aiming at establishing cooperative farm villages. Major investments were made in the primary education and health care. As a result the enrolment rate of the primary education soared up and the role of Kiswahili as the language of instruction in the basic education was established.

2.1.3 Socio-economical situation

Tanzania has a population of 35.9 million with annual growth rate of 2.0% (World Bank, 2005a). It is estimated that nearly 65% of the people live in rural areas (World Bank, 2003). One of the socio-cultural and ethnological features of Tanzania is its ethnic diversity with more than 120 different ethnic groups. Its salient feature is that none of the ethnic groups dominates the population, which is a rather unique existence in African countries. Despite its ethnological diversity, Tanzania is described as "*one of the politically most stable countries in Africa*" (World Bank, 2005b).

Tanzania is currently ranked as one of the least developed counties in the world. Its per capita income (GNI) in 2003 was estimated about US$300 (World Bank, 2005a). The economy is largely dependent on agriculture, which accounts for 45% of the GDP (World Bank, 2004a) and provides around 55 % of the total merchandise exports (URT-NW, 2005). However, most of the farmers are engaged in subsistence farming, growing maize, cassava, sorghum, millet, rice and bananas.

2.2 Education system in Tanzania

2.2.1 Structure of the education system

The structure of Tanzanian formal education system is described as 2-7-4-2-3+, that is 2 years of pre-primary education (O-level), 7 years of primary education, 4 years of secondary ordinary level education, 2 years of Advanced level education (A-level) and a minimum of 3 years of university education (Figure 2.2). Primary education is compulsory and free. After the age of 6, children are supposed to attend primary school. The medium of instruction in primary education is Kiswahili while English is taught as one of the compulsory subjects.

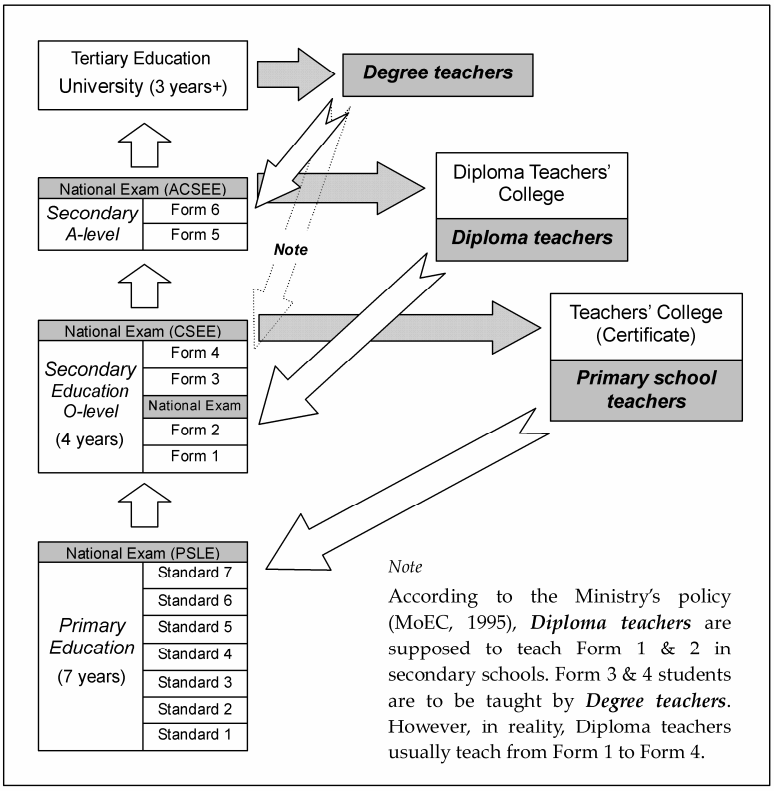


Figure 2. 2: The structure of education system in Tanzania

As described above, secondary education consists of two levels, **ordinary level** (O-level) and **advanced level** (A-level). The language of instruction in secondary school is English. In O-level, mathematics, Kiswahili, English and Civics are compulsory subjects in all secondary schools.

While in A-level, students major a combination of subjects which consists of three principal subjects and a few subsidiary subjects. Examples of subject combinations are PCM (Physics, Chemistry and Advanced Mathematics) and EGM (Economics, Geography and Advanced Mathematics). Secondary education is not compulsory and students' family must share costs by paying the school fee.

2.2.2 National examinations

At the end of each educational stage, Standard VII in primary, Form 4 in O-level and Form 6 in A-level, there is National Examination called, the Primary School Leaving Examination (PSLE), the Certificate of Secondary Education Examination (CSEE) and the Advanced Certificate of Secondary Education Examination (ACSEE) respectively. The national examinations are administered by the national examination authority described below. The results of the national examinations are used for selection for the next stage of education. In addition to the CSEE and ACSEE, there is another national examination at the end of Form 2. The Form 2 examination is essentially used for diagnostic purpose. However those who failed the examination must repeat Form 2, and if students fail it again, they have to leave the secondary school.

2.2.3 Teacher training

Teachers' training is conducted at Teachers' Training Colleges and the Universities. Diploma teachers' training colleges are responsible for the Certificate for primary school teachers as well as the Diploma for the secondary school teachers. Universities conduct teacher training for degree holders who are to teach in A-level and for Form 3 and Form 4 in O-level. Students who completed O-level secondary education can enter Teachers' Training College to become primary school teachers. While to become secondary school teachers, students must first complete A-level secondary education to start teacher education.

2.2.4 Educational authorities and policy of secondary education

The secondary education is highly centralized under the Ministry of Education and Culture (MoEC) which makes most decisions for management for the secondary education. While in the primary education, its administration and management are rather decentralized to regional and district levels.

Curriculum development and national examination are conducted by different parastatal semi-autonomous institutes respectively. The National Examination Council of Tanzania (NECTA) coordinates the preparation and distribution of examinations. The Tanzania Institute of Education (TIE) is the responsible institute for designing, developing, monitoring, reviewing and updating the national curriculum for all formal education. Until 1985, TIE was also providing school textbooks that would cover the curricula prepared by the TIE itself. Since then TIE does not actively produce textbooks, rather it concentrates on curriculum design and development as well as in-service training. However, in most of the O-level secondary schools, they are still depending of the textbooks published by TIE. The MoEC has the authority over these parastatal institutes through the chief education officer. And the MoEC monitors and maintains the qualitative standards of education through the School Inspectorate.

2.3 Policy issues in secondary education

2.3.1 Aims and Objectives

The Education and Training Policy stipulated by the MoEC in 1995 guides the curriculum policy and describes the aims and objectives of secondary education as follows (MoEC, 1995, p.6):

- To consolidate and broaden the scope of baseline ideas, knowledge, skills and principles acquired and developed at the primary education level.
- To enhance further development and appreciation of national unity, identity and ethic, personal integrity, respect for and readiness to work, human rights, cultural and moral values, customs, traditions and civic responsibilities and obligations.
- To promote the development of competency in linguistic ability and effective use of communication skills in Kiswahili and in at least one foreign language.
- To provide opportunities for the acquisition of knowledge, skills, attitudes and understanding in prescribed or selected fields of study.
- To prepare students for tertiary and higher education, vocational, technical and professional training.

2.3.2 Number and type of secondary schools

As of April 2005, there were totally 1,697 secondary schools registered by the Ministry of Education and Culture. The number of government secondary schools was 1,158 and that of non-government schools was 539. The number of secondary schools is increasing by month. The government schools are categorized into two types; (i) (pure) government secondary school and (ii) community secondary school. The (pure) government secondary schools are run by the government. While the community secondary schools are constructed through the community's contributions and run by the school board. Regardless the type of schools, the government is responsible for the employment of teachers and the supply of teaching and learning facilities for all the government schools. The non-government schools are built and managed by a non-government organization such as local NGO or religious organization, and the teachers are employed by the owner of the school. Private schools include both a few relatively endowed schools and a majority of poor equipped secondary schools.

2.3.3 Low enrolment, low transition rate and inequities

Historically, Tanzanian education policy, along with the philosophy of "*Education for Self Reliance*" proclaimed by the first president late J.K.Nyerere, put much emphasis on the primary education. As a result secondary education was reduced to become an "*elite manpower supplying system*" for the public. This "*primary education is terminal*" policy contributed to rationalize the elitist secondary school curriculum (O-saki, 2004b p.2).

Secondary education is still functioning as an elite selecting mechanism in Tanzanian. In principle, the students who pass the national examination at the end of primary education are supposed to enter to secondary education. However due to the shortage of secondary schools, not all of those who passed the examination are selected for secondary school.

Figure 2.3 shows a comparison of the number of students at some levels in primary and secondary schools in 2001. It can be found that only 1 % of the Standard I pupils (Std I) at the primary schools may reach up to the end of secondary education (i.e. Form 6).

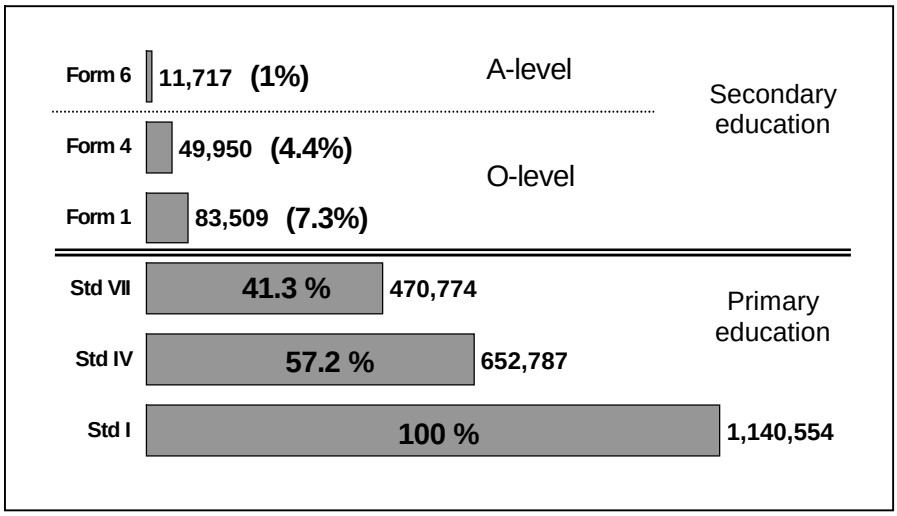


Figure 2. 3: Comparison of the number of students at stages in 2001

Source: Made from MoEC (2002).

The Tanzanian education policy focuses on improvement of four major aspects of education: *access*, *equity*, *quality* and *management*. Since the independence, "*the focus of education policy has been on the distribution and equalization of education opportunities through the expansion of the system at all levels…. The emphasis now is on the improvement of quality of education*" (MoEC, 1995, p.17). However, the large inequality in access is still an urgent political issue in Tanzania as is often the case in other African countries.

2.3.4 On-going educational reform in the secondary education: SEDP

In June 2004, with a strong initiative of the World Bank and donor countries which provided the Tanzanian government with financial support, the government launched the Secondary Education Development Programme (SEDP). The major aims of the SEDP is to: (1) increase the access with equity, (2) improve quality (learning outcomes of students, especially among girls), and (3) improve administrative management in the secondary education (World Bank, 2004b). With regard to quality improvement, SEDP includes (a) curricula and examinations reforms, (b) provision of textbooks and teaching materials through capitation grants to schools, (c) quality improvements in pre-service teacher training together with establishment of a system for professional in-service teacher development (World Bank, 2004b).

One of the concerns in the implementation of SEDP is that the rapid expansion of secondary education may bring about obstacles to the improvement of quality of education. Stronkhorst (2001) argues that, in many developing countries, a rapid expansion of formal education resulted in "*shortcomings in learning conditions in schools, shortcomings in the training of teachers, high dropout rates of students, low motivation of teachers, and relatively low educational achievements*"(, p.29). O-saki (2004a) warns that a rapid increase of student enrolment brings to the school a group of low level students who may not be able to follow the subject contents in the current "*elite curriculum*" (p.16).

2.4 Language issues

In Tanzania, as in many African countries, the language of instruction in education is a complicated and sensitive issue which involves academic, political and social discussions. In particular, the language of instruction in secondary education has been the most controversial issue. When considering how to support student learning in science and mathematics in secondary schools in Tanzania, the language issue cannot be put aside in the practice.

2.4.1 Linguistic situation in Tanzania

In contrast to many other African countries, Tanzania which has about 120 vernacular languages inside the country developed Kiswahili as the lingua franca of the society. Kiswahili is the "national language" as well as the "official language" in Tanzania. It is the language of "*day-to-day communication*" between different ethnic groups and spoken by more than 90% of the population (Rubagumya, 1991; Roy-Campbell & Qorro, 1997). In fact, for most of Tanzanians, Kiswahili is the second language. They are multilingual in a vernacular(s) and Kiswahili. However the number of people who speak Kiswahili as the first language is rapidly growing (Brock-Utne & Holmarsdottir, 2004).

Kiswahili is the language of instruction in primary education. In primary schools, textbooks are written in Kiswahili, and teachers and students communicate in Kiswahili. Children learn their

first literacy skills through Kiswahili. In secondary school, the language of instruction is changed from Kiswahili to English. However, students as well as teachers use Kiswahili for most communication even inside the school (Roy-Campbell & Qorro, 1997).

In Tanzania English is another official language. English was introduced into Tanzania as a colonial language by British colonial administration. In the present day English is used by about 5% of the population (Schimied, quoted in Roy-Campbell & Qorro, 1997, p.104). "*It is mainly used for international communication in politics, trade and commerce*." The use of English as an official language is limited to *"very formal situations, or situations where foreigners are involved*" (Roy-Campbell & Qorro, 1997, p.104). Despite its official status, English language is still a "*foreign language*" in a sense that "*children are not exposed much to [it] outside of school*" (Brock-Utne, 2003, p.3). Brock-Utne (2003) describes: "*English is to most Tanzanians a truly foreign language that they do not feel comfortable communicating in even after having had it for nine years as language of instruction*" (p.4).

2.4.2 Government language policy

Government policy describes the significant role of both languages, Kiswahili and English.

> "*Mastery of Kiswahili consolidates Tanzania culture while the English language will access Tanzanians to knowledge, understanding, science and technology, and communication with other countries*" (MoEC, 1995, p.52).

However, when looked at Education, Tanzanian language policy is described as "*confusing, contradictory and ambiguous*" (Brock-Utne & Holmarsdottir, 2004). Roy-Campbell & Qorro (1997) contend that Tanzanian education policy has been in "*disharmony*" with educational objectives, and they maintain the language situation in Tanzanian secondary schools as "*language crisis*". They describe the situation:

> "*Our situation is one where the government directs that the English language shall be the medium of instruction while admitting that students do not understand English; where teachers have to teach in Kiswahili to enable students to understand but, because of policy requirements, they have to set examinations in English; and where the students, because they received most of their instruction in Kiswahili, fail to do well in examinations which are conducted through the English language*" (p.13).

Researchers both Tanzanian and foreigners contend that "*Kiswahili is the most effective language of teaching and learning through the Tanzanian educational system*" (Arthur, 2001, p358). Based on their research findings, they recommend that the language of instruction in secondary school is to be changed from English to Kiswahili (Brock-Utne 2003; Brock-Utne & Holmarsdottir, 2004; Roy-Campbell & Qorro, 1997; Roy-Campbell, 2001, Rubagumya, 1991). Tanzanian government has also repeatedly issued a policy statement to extend the use of Kiswahili to the secondary and tertiary education. However, the government has failed to put it into practice (Arthur, 2001).

2.4.3 Language practice inside classroom in secondary school

In spite of the government policy, in real classroom practice, English needs to be supplemented by Kiswahili because students have problems in communicating in English (Rubagumya, 1991; Roy-Campbell, 2001; Brock-Utne,2003; Brock-Utne & Holmarsdottir, 2004). Especially the low grade students who have low English proficiency have serious problems in understanding

subject contents due to the language (Brock-Utne & Holmarsdottir, 2004).

In an effort to support student learning, teachers usually employ a strategy called "code-switching" (using both English and Kiswahili sentences alternatively) or "code-mixing" (using Kiswahili words within an English sentence or vice versa). Teachers use Kiswahili in class in order to express themselves effectively and for students to understand their explanations. Kiswahili is the "*de facto language of instruction*" in many classrooms (Brock-Utne & Holmarsdottir, 2004, p.74). The strategies used by teachers may be a practical solution, but they also create another problem when it comes to the tests or the national examinations which are set in English. Students face difficulty in understating the meaning of questions and in writing their answers in English. Rubagumya (1994) describes dilemmas Tanzanian secondary school teachers are facing.

> "*…. they [teachers] have to prepare their pupils for the examination. They want their pupils to understand what they are taught (so they resort to teaching in Kiswahili, thereby defying the regulations). They also know that the examinations, which are the only criterion for "success" or "failure", are in English. They therefore have to strike a delicate balance between all these diverse demands, and it is not an easy job. The outcome of this is that teachers tend to "spoon-feed" their pupils in preparation for examination, and this in turn promotes role-learning on the part of the pupils.*"(p.52)

2.4.4 Social aspect of language issue

Barrett (quoted in Roy-Campbell & Qorro, 1997, p.120) gives reasons for the political reluctance to change the language of instruction. One reason is the "*inevitable consequences of Tanzania's subordinate position in the world economy*" in which English is seen as the language of science and technology. Another reason is pertained to the benefits of groups of people which involve Tanzania's "*bureaucratic bourgeoisie and the Western countries*". Roy-Campbell (2001, p.271) describes "*The imposition of a monolingual education policy, with English as the language of instruction has served an "elite section" of the populations and their children*."

The government persistence to the policy of English as the language of instruction in secondary schools seems to have its root not only in an "elite section" but also in more wide socio-economic layers in Tanzania society. Despite the dominant function of Kiswahili, it is also pointed out that English is still regarded as the language of "*high status knowledge*" in the Tanzanian society (Roy-Campbell, 2001, p.273). Rubagumya (1994) also maintains that Tanzanian teachers use code-switching in such a way that it reinforces, consciously or unconsciously, the view that "*English is more appropriate for academic work than Kiswahili*"(p.45).

It is also noteworthy that those students who have difficulty in understanding English in classroom are convinced that they need to improve their English proficiency for better future and are really trying to cope with the situation. They may not understand well teachers' explanation in English but they believe that the best way to learn a foreign language is to have it as the language of instruction. In Tanzania, "*being educated is almost synonymous with being proficient in English*" (Rubagumya, 1994, p.51). When considering an instructional intervention to support student learning in Tanzania, these complexity and sensitivity in the language issue must be taken into account.

2.5 ICT policy and implementation in secondary schools

2.5.1 Government ICT policy

The ICT policy of Tanzanian government made by the Ministry of Communication and Transport (MoCT) describes that Tanzania is now facing "*dangers posed by the digital divide, and the risk of being excluded further from knowledge economy and social development*" (MoCT, 2003, p.1). Considering the current low level of human capital in the use and management of ICT, the Tanzanian ICT policy stipulates objectives and strategies of ICT implementation in various areas including education. The policy paper analyzes that "*the lack of a programme for training teachers on computers and other multi-media utilization is one of the constraints for expanding the computer education in schools*" (MoCT, 2003, p.4). The paper also states that the use of ICT can enhance effective delivery of education, including "*curriculum development, teaching methodologies, simulation laboratories, life-long learning and distance education*" (ibid, p.13). Recognising the low capacity of human capital, local content creation, ICT infrastructure and access, the ICT policy emphasizes the significance of increasing the size and quality of ICT skilled human resource in order "*to enable Tanzanians to participate meaningfully in the knowledge economy*" (MoCT, 2003, p.1).

2.5.2 ICT Implementation in secondary schools

In spite of the government ambitious policy to enhance ICT education in secondary schools, ICT implementation has not been realized yet in most secondary schools due to various constraints. After issuing the syllabus of the computer subject "*Computer studies*" for secondary education in 1997, the Ministry of Education and Culture called for all the government secondary schools to prepare a room for computer laboratory. Following the Ministry's notice, many government schools prepared a computer laboratory, however "*only few schools received the computers that were promised by the government*" (Tilya, 2003 p.13). Even if schools had had received computers, very few teachers would have been capable of teaching the new computer subject.

Nowadays computers have spread in many working places in Tanzania. Particularly in large cities, it is not rare to see a computer even in secondary schools. Schools are donated a computer by various organizations or local communities, or buy a second hand or even new computer by themselves. However, in many cases, the computers are mostly used for administrative purposes and not for instructional purposes (Tilya, 2003).

There are some secondary schools which have dozens of computers in computer laboratory. Schools are donated computers by various organizations or local communities, or buy second hand or even new computers by themselves. In many cases, the computers are mostly used for administrative purposes and not for instructional purposes (Tilya, 2003). Some of these schools are teaching students computer literacy as a subject following the syllabus. However the syllabus of Computer studies is rather examination oriented with more theoretical contents. In addition, the subject of Computer studies is not included in the compulsory subjects in the national examination (Tilya, 2003). As a result, many schools stopped following the computer syllabus and now are teaching basic software applications such as word processing, spreadsheet and database. Most schools do not use computers as "teaching/learning tools" in other subjects (ibid).

Administrative use of ICT in schools

Most dominant use of computers in secondary schools is for administration. Many schools firstly introduce a computer for the sake of secretary works. The computers make the

documentation work easy, speedy, effective and also good in appearance. Although it has little to do with curriculum, it is the first step for the implementation of ICT in schools.

One example of innovative use of computer may be seen in the process of examination setting. In Tanzania, many schools are still using a manual typewriter and an old printing machine to print documents and examination papers. When they prepare examinations, each teacher prepares a manuscript of his or her question papers and hands it to the school secretary who types the questions on a stencil sheet with a type writer. The question paper will then be printed with a printing machine called duplicating machine. The quality of printed papers is usually not good. There may be typing miss on the stencil. And it is not easy to draw diagrams or scientific signs with a type writer, so they usually draw diagrams on the stencil with hand, which is another cause of the poor printing quality. In order to solve this problem, some schools have introduced a computer and use it to print test papers. Computer can be connected to an electric dot matrix printer. The printer can directly type on the stencil sheet which can be used for the old duplicating machine. This new printing procedure greatly improved the quality of printing materials in schools.

ICT literacy lesson

As mentioned before, there are secondary schools which have a computer laboratory equipped a certain number of desktop computers. They are using the computers to teach basic computer literacy, mainly the use of basic applications, as an optional subject within a school time table. Schools often employ a computer instructor outside the school for the computer lesson. It should be noted that the computer lessons are held in the computer lab and the computers are hardly used for other subject lessons.

2.6 Summary - Implications to the study

This chapter provided contextual information of Tanzania focusing on some key issues related to the study. As the summary of this chapter, the following paragraphs discuss some implications gained in this chapter.

The impact of the current on-going educational reform on the students' performance in secondary schools is an important concern. As a result of the rapid increase in the enrolment in secondary education, it is expected that the population of low achievers in the school also increases. It is of great importance for the secondary school to find some appropriate measures to support student learning for those latent slow learners. It is also important for the school to identify those who have poor academic background at an early stage of secondary education, so that they can be given an appropriate guidance and support for their studying in secondary schools. When considering the design and use of supplemental teaching/learning materials, it seems important to take these implications into consideration.

The language of instruction in secondary schools is another important concern in this study. In Tanzania, many secondary school students are struggling in their learning because of English language which is the instruction medium in the schools and yet a foreign language to most of the students. Although it is not easy to find a clear cut solution for the problem, a tentative practical approach needs to be sought as teachers do in classroom using the strategy of "code-switching" and "code-mixing" in an effort to support student learning in secondary schools. Such a pragmatic solution may need to be an informal approach because the official approach is supposed to follow the government policy.

The limited implementation of ICT in most secondary schools in Tanzania had several implications to this study. For example, because many secondary school teachers were expected not to have much experience and skills in using ICT, the activities designed for ICT training for teachers had to be carefully chosen so as not to be too difficult and too complicated for the participant teachers. Similarly due to the limited ICT use, the intended interventions in this study (i.e. Promoting teachers' use of ICT for making teaching/learning materials) was likely to be seen by teachers as a new and extra activity for them, which indicated that it was important to consider teachers' perception and motivation towards the intended practice. Moreover, it was expected that finding the schools to conduct the field research was the first critical point in the study.

In this chapter one important aspect of education: *curriculum* was not described. In the next chapter, some of the curriculum issues are discussed in relation to the problem of poor performance in science and mathematics focusing on sub-Saharan African countries.

Chapter 3

Literature review

This chapter presents the findings and insights gained from the literature review. After a brief introduction in section 3.1, a preliminary analysis on the problem of students' poor performance in science and mathematics are described in section 3.2. Section 3.3 discusses three key words: motivation, visual representation and language support which appeared relevant in this study from the problem analysis made in the section 3.2. Section 3.4 gives discussion as to the use of ICT in secondary schools focusing on sub-Saharan African countries. Section 3.5 presents practical tips learnt in the literature for designing an in-service training programme. Section 3.6 briefly summarizes the chapter.

3.1 Introduction

This study assumes two things: (i) potential roles of supplemental teaching/learning materials to support student learning and (ii) potentials of ICT to facilitate teachers' practice of making such materials in schools. In order to build theoretical and empirical foundations for the study, the literature was reviewed to explore tentative explanations to the following questions.

- *What problems are attributed to the students' poor performance in science and mathematics in secondary schools in sub-Saharan African countries, especially in Tanzania?*
- *How (For which problems) may supplemental teaching/learning materials play a role to support student learning in science and mathematics?*
- *What characteristics or design features are important and relevant for the supplemental teaching/learning materials to support student learning in science and mathematics?*
- *What need to be considered when designing an in-service training programme to promote teachers' use of ICT for making supplemental materials in secondary schools in Tanzania?*

Firstly the problem of student poor performance in science and mathematics is preliminary analyzed, and then, based on the analysis, design principles of supplemental teaching/learning materials are discussed. The third part of the literature review focuses on ICT training, and lastly, practical hints for designing an in-service training programme learnt from the literature are described.

3.2 Problem analysis

Students' poor performance in mathematics and science subjects is not only the problem in Tanzania, but it has also been a controversial issue in other sub-Saharan African countries (de Feiter *et al.*, 1995; Githua, & Mwangi, 2003; Gray, 1999; Howie, 2002; Ogunniyi, 1996; TIMSS, 2004; Todd & Mason, 2005). Considering the fact that student performance is influenced by various factors at different levels, it can be expected that a variety of problems are attributed to the students' poor achievement. This section attempts to make a preliminary analysis on the problem and describes several factors attributed to the problem in the literature.

3.2.1 Factors attributed to students' poor performance in science & mathematics

A variety of factors are described in the literature as influencing factors on students' performance in science and mathematics. Some studies provide a model to illustrate a relationship amongst these factors. For example, Ogunniyi (1996) made a list to classify a number of factors into eight groups as below.

i) ***Family*** related factors – e.g. *socio-economic status, support, discipline, etc.*
ii) ***Society*** (& community) related factors – e.g. *cultural & traditional belief, etc.*
iii) ***Government*** (i.e. education system & policy) – e.g. *ideology, teacher training, etc.*
iv) ***School*** (& classroom) related factors – e.g. *management, resource, facilities, etc.*
v) ***Teacher*** related factors – e.g. *qualification, teaching experience, competence, etc.*
vi) ***Student*** related factors – e.g. *academic background, motivation, aptitude, etc.*
vii) ***Subject matter*** (& curriculum) – e.g. *nature of subjects, content of curriculum, etc.*
viii) ***Examination*** related factors – e.g. *quality, quantity and mode of exam., etc.*

These factors may influence directly or indirectly students' performance at different level, and the factors are also inter-related to each other. Some factors are beyond the reach of educational practice (e.g. socio-economic factors and students' home background). Other factors such as policy and education system are beyond the scope of this study since they are not easily changed by an intervention at school level.

When focused on the factors which seem more directly related to teaching learning practice in schools, the following items are often described in the literature as influential factors of students' poor performance in science and mathematics (Chonjo *et al.*,1996; de Feiter *et al.*, 1995; Howie, 2002; Kitta, 2004; O-saki, 2004a; Roy-Campbell & Qorro1997; Todd & Mason, 2005; Tilya, 2003; Tilya & Voogt, 2002).

- Learning materials (e.g. Textbooks)
- Classroom instruction
- Teachers' competencies and motivation
- Students' academic background
- Students' self-concept, confidence and motivation to learn science subjects
- Nature of science subjects
- Syllabus
- National examination
- Language of instruction

The following sub-sections discuss these factors and their impact on students' performance in science and mathematics.

3.2.2 Learning materials

The literature indicates that, in developing countries, school related factors have a greater influence on students' achievement than other factors (de Feiter *et al.*, 1995; Howie, 2002). It is also described that simple material conditions such as availability of textbooks in schools have a significant effect on student performance (Fuller, quoted in de Feiter *et al.*, 1995), which is a contrast to industrialized countries where the students' socio-economic background and other extramural factors have more strong influence (de Feiter *et al.*, 1995; Howie, 2002).

In Tanzania, it was reported that many schools had a shortage of resources such as textbooks, reference books and teaching aids (e.g. Chonjo *et al.*, 1996; Kitta, 2004). Schools are supposed to

provide textbooks to each student, however in many cases, the number of textbooks is not enough, and students need to share one textbook with some students. Those who can afford to buy textbooks have their own but the majority can not (Chonjo *et al*., 1996).

In addition to the shortage of textbooks, the quality and adequacy of textbooks are also found as another problem. Chonjo *et at*., (1996) concluded, based on their study on the textbooks which were used in secondary schools in Tanzania, that textbooks produced by the national curriculum institute and local publishers were "*neither easier to read nor more appropriate in their content and illustrations*", than some of the imported textbooks (p.69).

Roy-Campbell & Qorro (1997) pointed out the problem of inappropriate linguistic level of the secondary school textbooks in Tanzania. They contended that the school textbooks caused frustration to students, since the textbooks were made without taking into account the students' linguistic level in English. This linguistic problem of textbooks is a serious concern especially for lower grade students considering their limited exposure to English before entering secondary schools. They also mentioned that there was a "generally held view" amongst the curriculum developers that simplifying English in the school textbooks at the secondary school level was "*only helping to bring down the standard of English further*"(ibid, p.55).

3.2.3 Classroom instruction practice

The literature argues that student performance is strongly related to teachers' instructional practice (Chonjo *et.al*., 1996; Howie, 2002; Kitta, Thijs & van den Berg, 2002).

A number of studies describe the characteristics of typical classroom practice observed in 1990s in sub-Saharan African countries (e.g. Chonjo *et al*., 1996; de Feiter *et al*., 1995; Tabulawa, 1997). What they commonly observed was that most teachers used a "*transmission (chalk and talk) approach*" rather than an "*interactive, learner-centred pedagogy*" and that "*the teachers were seen to be authoritative, dogmatic and inflexible*" (Tilya, 2003, p.8)" which Tabulawa (1997 p.202) describes as "*authoritarian pedagogical style*". Although some of these observations were made nearly ten years ago, the classroom situations seem not to have drastically changed since then in many sub-Saharan African countries (e.g. Motswiri, 2004; O-saki, 2004a; Stronkhorst, 2001)

De Feiter *et al*., (1995, p.45), quoting the work of Prophet (1990) who studied in Botswana and that of Stuart (1991) in Lesotho, summarizes characteristics and problems of the "chalk and talk lecture method" as below.

- Most teaching was "formal and didactic" (i.e. question, answer and teacher exposition). Teachers talked most time (85%) and the rest (15%) was for answering pupils' questions.
- Pupils were mostly passive. They seldom asked questions or "initiated an exchange of thoughts".
- Teacher accepted only correct answer and tended to ignore incorrect answers given by students.
- Teachers' questions demanded only "basic recall and comprehension", often as "single words or short sentences". Teachers rarely posed such questions as asking "comparing, inferring, reasoning and evaluating."
- Teachers' lectures did not present "models of higher cognitive skills".
- Pupils engaged in only "simple whole class activity" such as "filling in correct answers in worksheets (if available)".
- Teachers gave only theoretical explanation and rarely conducted practical work often because of lack of time or equipment.

O-saki (cited in Tilya, 2003, p.8) observed in Tanzanian secondary schools, that students tend to depend too much on teachers' notes even if they have textbooks. Teachers' notes are the main source of information for students, and students attempt to remember the given contents by *rote learning* in order to pass examination. The overdependence of factual memorization is attributed to the students' poor understanding of subject contents (Chonjo *et al*., 1996).

As described above, various shortcomings are attributed to the "*authoritative teacher-centred instruction*" in secondary schools in sub-Saharan African countries. However, it should be noted that the examination results are not necessarily directly related to the teachers' pedagogical style. Stronkhorst (2002, p.192) gives a description of one of the participant teachers in his study. The teacher was an "*experienced chalker & talker*" having already adopted a "teacher-centred approach" for long time. He gave comprehensive and detailed "textbook replacing" notes during lessons even when all students had a good textbook, and he had a strong belief that "*students only learn for tests or exam*". And the fact was that the examination result of his students was outstanding. Teacher-centred lecture methods may also have pedagogical merits as "*an efficient means of conveying a body of information when there is too little printed material, or the teachers' ability to control the direction of content in the classroom*" (Blight, cited in Tilya, 2003, p.8).

It is also pointed out by many researchers that, teachers' pedagogical styles have much to do with their socio-cultural belief and traditional value in African societies. (e.g. de Feiter *et al*., 1995; O'Sullivan, 2004; Shumba, 1999; Tabulawa, 1997). In addition, student' learning strategies may also have a root in their socio-cultural value and practices. Therefore it is not easy (and may not be relevant either) to promote dratical pedagogical changes which may not be in line with the belief and usual practices of teachers as well as students.

3.2.4 Teachers' competence and motivation

In many sub-Saharan African countries, the expansion of student enrolment and the increase of secondary schools have resulted in a shortage of qualified teachers. In addition, due to the ineffective pre-service teachers' training, it is said that there are secondary school teachers who have problems of insufficient subject matter knowledge and teaching skills. Kitta (2004) describes:

> "*…those who are qualified to teach have significant problems due to the poor teaching preparations they received in college*". "*The majority of these teachers lack substantial subject matter knowledge, the knowledge of what to teach, and how to teach the subject matter effectively.*" *(p.2)*

It is also argued that teachers' lack of motivation for teaching is one of the problems in secondary school. Chonjo *et al*. (1996) describes how secondary school teachers were de-motivated and de-moralized in Tanzania.

> "*Teachers are not motivated…. Their salary is so low that all teachers are forced to do some business in their free time and also during school hours. Lesson preparations suffer, this leads to tensions with pupils and the management.*"*(p.7)*

As teachers are directly involved in the teaching and learning practice in schools, the problems of teachers are to have a significant impact, directly or indirectly, on student performance.

3.2.5 Students' academic background, self-concept and motivation

The literature also points out that lack of students' basic knowledge is one of the causes of poor performance amongst secondary school students in mathematics and science subject (Chonjo *et al*., 1996; Howie, 2002). Chonjo *et al*. (1996) found in their researches conducted in Tanzania, that there were students in secondary schools who had limited mathematical skills and could not properly read and understand the meaning of graphs. Roy-Campbell & Qorro (1997) showed poor reading skill of English amongst Tanzanian secondary students.

These problems are often attributed to poor pedagogy and an adverse teaching/learning environment in primary schools (Chonjo *et al*., 1996). However, once students enter secondary schools, it is the responsibility of secondary school teachers to support and enhance students' understanding of basic subject contents. One problem is that, in secondary schools, teachers do not have appropriate teaching/learning materials which can be used to give remedial support to the low achievers, and that secondary school textbooks are basically not designed for such a remedial purpose.

Personality characteristics such as "*academic self-concept*"[2] and students' motivation to learn science subject are other important factors influencing student learning in mathematics and science (e.g. Githua & Mwangi, 2003). Howie (2002) maintains that the more students have positive self-concept, the better they perform in mathematics. To increase students' motivation for learning mathematics and science, students need the experience of feeling success in their learning (Keller, 1983; Keller & Suzuki, 2004). According to instructional motivation theories, it may also be desirable to use learner-friendly, sometimes informal and casual, learning materials so that the materials can inspire students' curiosity and increase their motivation to learn science subjects (ibid). Such supplemental care needs to be offered before students evolve negative impression or the notion of "*helplessness*" in the subjects (Ma, cited in Howie, 2002).

3.2.6 Nature of science subjects and syllabus

Scientific knowledge, as described by Matthews (2002), is:

> "*…in large part abstract (depending on notions such as velocity, acceleration, force, gene), that is removed from experience (propositions about atomic structure, cellular processes, astronomic events), that has no connection with prior conceptions (ideas of viruses, antibodies, molten core, evolution, electromagnetic radiation), and that is alien to common-sense, and in conflict with everyday experience, expectations, and concepts.*" *(p.129)*

The complex, abstract and alien nature of scientific concepts or phenomena as well as specialized scientific terminology are to be one of the factors which make it difficult for students to learn science (Gray, 1999). In order to support student learning, these subject natures also need to be taken into account.

In addition to the subject nature, science curriculum in secondary education in sub-Saharan African countries is often criticized for its *overloaded contents* and *irrelevance* to the students' learning environment (Chonjo *et al*., 1996; O-saki, 2004a). It is also argued that the syllabi emphasize factual information and that there is little emphasis on practical work (Kitta, 2004), which may cause students to be cognitively overloaded with the factual information. There is a

[2] Academic self-concept is defined as a "person's assessment of academic ability" or "academic self-image which learners develop generalized image of themselves as learners" (Smith & Ragan, 1999).

criticism for a large gap between the "*intended curriculum and the operational curriculum*" (van den Akker, 2003) observed at classroom level. O-saki (2004a) describes the situation of student learning in secondary schools in Tanzania.

> "*Syllabuses are long, with a heavy content, they suggest that practical work should be done regularly, but schools lack resources, including well trained teachers, a conductive environment and appropriate teaching and learning materials…..Students may pass physics, chemistry, biology, but have little understanding of the concepts they have learned other than committing the definitions, laws and principles to memory.*" *(p.15)*

3.2.7 National Examination

In sub-Saharan African countries, it is a common practice that the centralized national examination takes place at the end of secondary education cycle. The role of the examinations is not only assesses the students' achievement but also to select students for further academic steps. Reflecting on the examination system in Tanzania, Chonjo *et al*. (1996, p.85) state that "*in a highly selective education system examinations are a sensitive issue, as they become the ultimate goal of teaching and learning and have undesirable backwash effects on the quality of teaching*".

With regard to the poor results in science and mathematics examinations, the quality of national examinations is criticised as one of the causes of the problem. Chonjo *et al*.,(1996, p.89) described problematic features of the national examinations in Tanzania, which included the "*heavy emphasis on factual knowledge to be recalled*", "focusing narrowly on definitions and terminology", and stressing "*the vocabulary of science, rather than its ideas, its explanations, and its applications to everyday life*".

The language used in the national examination has also significant effect on the students' performance as it works as a barrier for students to explain their answers (Chonjo *et al*.,1996; Roy-Campbell & Qorro, 1997). Referring the analysis on examination results made by the National Examination Council of Tanzania, Chonjo *et al*., (1996) describe:

> "*Where they were asked to explain in their own words particular principles or laws, the results showed that candidates seemed to have an idea of the right answer but failed to communicate it in English accurately and markers were unable to find sense in their responses.*" *(p.88)*

It should be noted that, in sub-Saharan African countries in general, the result of national examination has a significant meaning for students' future career. "*Examination results are normally used by employers and institutions of further education and training as one of the criteria for selecting applicants to relevant post and training opportunities*" (Mwaluko, 1997, p.2). The impact of the examination results on students' career is prominent in girl students whose results in science and mathematics examinations are usually below than that of boys. The problem is manifested in a situation of low representation of girl students in science course at A-level secondary education as well as at university level in Tanzania (Mwaluko, 1997; Urassa & O-saki, 2002).

3.2.8 The language of instruction

Finally the language of instruction is another crucial factor which has a significant impact on teaching and learning process. When looked at the situation of secondary education in many sub-Saharan African countries, where "*students learn through the medium of a second language,*

most often from teachers for whom it is also a second language" (Gray, 1999, p.263), it is evident that the language of instruction has a significant influence on student learning in schools in the African countries.

Howie (2002) concluded, from her extensive data analysis on the result of an international mathematics achievement test (TIMSS 2003) in South Africa, that "*When pupils are compelled to learn through a second language, this can become a serious obstruction in the pupils' learning process and that the final outcome many be negatively influenced*" (p.245).

Setati (2005, p89), referring an extensive review made by Secada (1992) on bilingual education and mathematics achievement, presents some findings as to the impact of the language of instruction on student learning as below.

- There is a significant relationship between the development of language and mathematics achievement.
- If only English is used as the language of instruction, low oral proficiency in English affects mathematics achievement negatively.
- In multilingual primary mathematics classrooms in South Africa where English is not the main language of the learners, using English only as the language of instruction has a negative effect on the learners' "meaning making" and problem solving.
- In classrooms where English was the only language used for teaching and learning, learners have difficulty in engaging "procedural and conceptual discourse".
- First year students in South African university who were learning mathematics in English, which was not their main language, had difficulty in understanding mathematical terms such as integer, perimeter, and multiple.

As previously described in the context of Tanzania, the issue of language is a complex and sensitive matter in African countries as it involves not only academic affaires but also political, socio-cultural and economical debates. The points of debate vary depending on the linguistic situation of each country (Arthur, 2001; Benson, 2004; Brock-Utne & Holmarsdottir, 2004; Chonjo *et al.*, 1996; Gray, 1999; Roy-Campbell & Qorro, 1997; Rubagumya, 1991, 1994; Setati, 2005). The impact of the language of instruction on learning is discussed later in this chapter in relation to the design principle of supplemental teaching/learning materials.

3.2.9 Summary and implication for the study

There are a variety of problems attributed to the poor performance of secondary students in science and mathematics in sub-Saharan African countries. When looked at the problems which are more directly related to teaching learning practice in schools, the following problems are often identified in the literature.

- Lack of learning materials, and inadequacy of textbooks
- Inefficient classroom instruction
- Lack of teachers' competencies and motivation
- Students' poor academic background
- Students' low self-concept, low-confidence and low-motivation for learning science subjects
- Abstract, imaginative and alien nature of mathematics and science subjects
- Heavy content syllabuses
- Problems of the quality and mode of the national examinations
- Students' low proficiency of the language of instruction

In order to improve students' performance, these problems must be dealt with several approaches in a variety of ways. In this study, one assumption is that the supplemental teaching/learning materials may play a role to deal with some of these problems.

When considering potential roles and design features of supplemental teaching/learning materials as a supportive measure of student learning in science and mathematics, based on the preliminary problem analysis attempted in this section, three *key words* appeared to have some relevance to this study. They are (i) *motivation*, (ii) *visual representation*, and (iii) *language support*.

Relevance of *motivation* to this study is found in two aspects. Firstly, when developing supplemental teaching/learning materials, it needs to take into consideration design features in order to increase students' motivation to learn mathematics and science subjects using the materials. Secondly, motivation is an important element in designing an in-service intervention programme to promote teachers' use of ICT for making supplemental teaching/learning materials.

Visual representations or visually appealing formats with diagrams, pictures and photos are expected to facilitate student understanding of abstract concept in science and mathematics. Especially for those who have difficulty in understanding English explanation, visual representations incorporated in text information would be helpful to support student learning.

As for the *language support*, as have already discussed, it is a rather complicated issue in sub-Saharan African countries, particularly in Tanzania. However, in order to find a way to improve student performance in science and mathematics, the problem of the language of instruction can not be neglected in secondary schools. The language support in printed materials given in a students' familiar language such as Kiswahili in the case of Tanzania seems to be one of the practical measures to alleviate the problem of poor performance in science and mathematics. The next section briefly discusses these three key words, and the insights gained in the literature are described.

3.3 Three key words - motivation, visualization & language support

3.3.1 Motivation

Motivation is an important factor to affect student learning and performance. Motivation has relevance to this study in at least two aspects. Firstly, motivation is an important element when considering the design and effective use of supplemental teaching/learning materials to facilitate student learning. Secondly, in order to promote teachers' practice of using ICT tools for making the supplemental materials, it is inevitably important to take teachers' motivation into account in the practice.

Motivation

Motivation may be defined as "*a person's desire to pursue a goal or perform a task, which is manifested by choice of goals and effort (persistence plus vigour) in pursuing the goal*" (Keller & Litchfield, 2002, p.86). "*Motivation is a complex internal construct embedded in personal experience, expectations and perceptions*" (ibid, p.88).

There are two distinctive motivations usually discussed in the literature. One is called ***intrinsic motivation*** and the other is ***extrinsic motivation*** (Keller & Litchfield, 2002; Smith & Ragan, 1999). The *intrinsic motivation* can be seen when learners are engaged in a task from their

personal interests and for their own satisfaction without expecting any apparent reword. While the *extrinsic motivation* is triggered by rewards associated with successful accomplishment of the task. An important consideration on motivation is that a stronger motivation can be achieved when the learner works on a task with *intrinsic motivation*. It is also noteworthy that *extrinsic motivation* may reduce learner's *intrinsic motivation* (Keller & Litchfield, 2002). It is therefore important to increase learners' intrinsic motivation using some tactics when supporting students' learning. Instructional theories such as Gagné's nine events of instruction (Gagnés, 1985) and Keller's ARCS model (Keller 1983; Keller & Suzuki, 2004) indicate that the instruction can play an important part to influence learners' motivation.

ARCS model

The ARCS model states that four major conditions: *Attention*, *Relevance*, *Confidence* and *Satisfaction*, are key components to raise and maintain learners' motivation (Keller 1983; Keller & Suzuki, 2004; Keller & Litchfield, 2002). The model provide some specific motivational strategies for each of the four conditions.

According to the ARCS model, the first important tactic to increase and maintain learners' motivation is gaining the learner's ***attention*** by, for example, using "*interesting graphics, animation or any kind of event*" to raise learners' perception, or stimulating "*a sense of inquiry in the learner*" (Keller & Suzuki, 2004). Another "*attention strategy*" is to incorporate "*variability*" in the task so that learners can maintain their interest over time. "*Humour*" can also be used to raise learners' interest by stimulating curiosity and drawing attention to the learning task (Smith & Ragan, 1999, p.264).

As for the second component, ***relevance*** is an important factor to raise learners' motivation. Relevance can be built by giving learners "*clear goals*" for the practice (i.e. *goal orientation*), and by providing "*authentic learning tasks*" which have connection with learners' interests, prior experience or familiarity.

Confidence is another important condition to increase learners' motivation. In order for learners to have strong motivation and to maintain a high motivational level, they need "*positive expectation for their success*" as well as real "*success experience*" under the situation where "*they attribute their successes to their own abilities and efforts rather than to luck or the task being too easy or difficult*" (Weiner, quoted in Keller & Suzuki, 2004, p.231), which makes the learners to have "*positive feeling about their learning experiences*" (ibid, p.231), and thereby build *self-confidence* for the task.

Finally "***satisfaction strategy***" can increase and maintain learners' motivation "*through management of the consequences of student activity and learning*" (Smith & Ragan, 1999, p.263). It can be achieved by providing extrinsic reinforcement such as *positive rewords* or *feedback* in such a manner that learners' intrinsic feeling of satisfaction can be enhanced. To maintain learners' intrinsic satisfaction, it is also important to consider the amount of task so that learners can feel "*equity*" or "*fairness*" on the given task (Keller & Suzuki, 2004; Smith & Ragan, 1999).

In addition to the motivational strategies, the ARCS model also provides a systematic motivational design model which shows an instructional design process to incorporate motivation strategies into the instruction. (See Keller & Litchfield, 2002; Keller & Suzuki, 2004 for further explanation.)

Implication

Motivation is an essential element for effective learning to take place. Its implication on the

design of supplemental teaching/learning materials is described in Chapter 5. Its relevance to the teachers' training is briefly discussed further later in this chapter.

3.3.2 Visual representation

Potential roles of visual representations on learning

It is generally acknowledged that tables, diagrams, pictures or photos can facilitate peoples' understanding of given information (e.g. Carney & Levin, 2002; Gellevij, van der Meij, de Jong & Pieters, 2002; Vikiri, 2002). Visual representation such as static pictures helps learners to understand and remember information in the accompanied text (e.g. Scheiter, Gerjets & Catrambone, in press). "*Illustration can make learning more enjoyable and evoke affective reactions, which in turn also enhance learning*" (Chonjo *et al*., 1996, p.66). The literature gives several theoretical and empirical explanations for the positive effects of visual representations on learning.

Levin and Mayer (quoted in Carney & Levin, 2002, p.9) proposed ***seven "C" principles*** to explain the reasons why pictures improve students' learning from text. They state that pictures make the text more:

- **concentrated** (focused, with respect to directing a reader's attention),
- **compact/concise** ("a picture is worth a thousand words"),
- **concrete** (the representation function),
- **coherent** (the organization function),
- **comprehensible** (the interpretation function),
- **correspondent** (relating unfamiliar text to a reader's prior knowledge), and
- **codable** (the mnemonic transformation function)

Cognitive psychological perspective

Cognitive information-processing theories explain the mechanism of human learning assuming internal processes in the brain. The hypothesized system called "*human cognitive architecture*" (Paas, Renkl, & Sweller, 2003) involves three memory systems: (i) sensory memory, (ii) short-term memory (also known as working memory) and (iii) long-term memory (Smith & Ragan, 1999). According to the cognitive psychology, visually appealing materials can support student learning by enhancing their information processing. For example, "*boldface and italic print*" in text explanation can serve to promote learners' attention to important information and facilitate the passage of the information through the *working memory*, which is the critical step for the learning to take place (Driscoll, 2002). Graphical representations such as diagrams, chart, map and images can also facilitate learning process by promoting integration of information in the working memory (Vikiri, 2002).

Information that is successfully processed through working memory is transferred and held in long-term memory (i.e. encoding). Long-term memory enables the learner to remember and apply the information in other situations. When people receive new information, the information held in the long-term memory is brought into the working memory (i.e. retrieval) to make sense out of the new coming information (Smith & Ragan, 1999).

It is suggested that visual representations help learners to "*make meaningful connections between their prior knowledge and the new information they are learning*" (Driscoll, 2002, p.62). Pictures can also increase the motivation of learners, focusing attention and enhance deep information processing (Peeck, 1993, quoted in Carney & Levin, 2002, p.10).

According to the dual coding theory (Mayer & Sims, 1994; Paivio, 1990), which hypothesizes that visual information is processed in a different memory system from verbal information, learning can be facilitated when the visual representation is provided along with text information. The theory suggests that visual information is encoded separately from verbal information in long-term memory. This dual processing enables learners to process more information with additive effects, which results in better learning.

Other considerations

It should be noted, however, that visual representations do not always enhance student learning and may even hinder the learning process (Carlson, Chandler & Sweller, 2003; Paas, Renkl & Sweller, 2003). In designing instructional materials, it is important to consider an effective arrangement of diagram and textual information (i.e. *split-attention effect*) and also the relevance of additional information for diagrams (i.e. *redundancy effect*). It is also noteworthy that the effects of visual aids may very depending on the task level and learners' cognitive style (Mayer & Massa, 2003) (For further discussion, refer to Paas, Renkl, & Sweller, 2003).

Jenkins (quoted in Carney & Levin, 2002, p.9) argues that the following four variables are important elements to consider the "*why*, *when* and for *whom*" of picture facilitation:

- desired performance outcomes (e.g., comprehension, memory, transfer),
- the nature of the illustrations (e.g., that they must be related to the text content),
- the nature of the text (e.g., the more difficult the text is to understand, the more that pictures help)
- learner characteristics (e.g., learners lacking domain-relevant background knowledge benefit more from illustrations)

When considering the design of supplemental materials, it is also important to note that visual representation may have positive and negative impact on students' affective aspects. For example, "*illustrations can play a strong role in reinforcing or counteracting gender biases, by providing role models for both teachers and students*" (Chonjo *et al.*, 1996, p.66). In this aspect, designers need to be aware of the gender so as not to be biased in terms of gender in the materials.

Implication

Although in this study, the quality and effectiveness of supplemental teaching/learning materials is not pursued as the main target, when designing supplemental teaching/learning materials, it is important to be aware of the theoretical rationales of visual effects in the materials and to make good use of visual representations to facilitate student learning.

3.3.3 Language support

As previously discussed, the language of instruction is a significant impact on student learning in secondary schools in sub-Saharan African countries. Although it is important to know the theoretical arguments on the linguistic pedagogical issues such as second language learning and mother tongue education (e.g. Cummins, 1999) when thinking about the impact of the language of instruction on student learning, since these arguments are beyond the scope of this study, this section aims to present some insights gained in the literature concerning the significance and expected roles of the language support to facilitate student learning in science and mathematics.

Language and learning

It goes without saying that language is an essential tool for human communication.

Socio-cultural theory (Vygotsky, 1978) asserts that "*learners and their socio-cultural contexts interact, assisting learners to develop cognitions that will enable them to adapt to their environments*" (Smith & Ragan, 1999, p.23). It indicates that interaction between teacher and students, and amongst students is an essential part for effective teaching learning in schools. Such interactions greatly depend on the language which they use. The role of language is not only for communication. Language also plays a significant role in conceptualization of an idea. Smith and Ragan (1999) describe that language is "*a social action*" and "*critical to the development of higher cognitive processes*" (p.23).

With regard to the role of language in science education, Gray (1999) maintains that "*the learning of science makes its own particular language demands, firstly because of the complex and often abstract nature of the concepts or phenomena involved, and secondly because of the specialized terminology that has evolved*" (p.263). He also goes to say: "*Language… is perhaps the single most significant obstacle to conceptual understanding in science that learners in the developing world face*" (ibid, p.263).

On reflection of the problems African students are facing to learn science in a foreign language, Dlodlo (1999) expresses a concern, saying: "*How can students be expected to reformulate ideas in their own words in a foreign language*?" (p.323). When people formulate an idea, he or she chooses words that must "*be necessary interpretive instruments of understanding*" (Sutton 1992 quoted in Dlodlo, 1999, p.323).

Dlodlo (1999) argues that, since English words used in science had no relation to students' everyday experiences, students may have difficulty in constructing meanings of the scientific concepts. If local language with which students communicate in daily life is used, students can more easily make a sense of scientific phenomena and construct correct conceptions.

Some considerations on the language support

Cummins (1981, 1986), quoted in Howie (2002, p.40), contends that children may acquire "*context embedded second language fluency*" in one or two years, but it takes five or seven years (or longer) for them to develop "*context reduced fluency*" which is essential to higher order thinking such as "*synthesis, discussion, analysis, evaluation and interpretation*". She maintains that, even if children show some "*conversational-level ability*" in a second language and give an impression that they are ready to learn in the second language, they may lack the "*context-reduced fluency*". As a result children have difficulty in understanding the subject content and often fail to engage in higher order cognitive process in the classroom.

With regard to the relationship between students' second language acquisition and their learning capacity in secondary schools, a notion "*zone of proximal development*" proposed by Vygotsky (1978) provide some hints for the use of language support in supplemental teaching/learning materials. Vygotsky (1978) referred to the *zone of proximal development* as the distance between the actual developmental level (i.e. what students can do on their own) and the level of potential development (i.e. what they can do with support of others who are more capable).

Smith & Ragan (1999) interprets the *zone of proximal development* as "*the type of problem-solving cognitions that are not possible for a learner independently but can be generated with the assistance ('scaffolding') of a teacher or more knowledgeable peer*" (p.23). *Scaffolding* is referred by Collins, Brown and Newman (1989, p.482) to the "*supports the teacher provides to help the student carry out a task*" such as suggestions or help. The support is supposed to be systematically withdrawn

("*fading*") as the students develop their skill or knowledge until they reach an enough level.

One of the examples of such a scaffolding can be found in the use of English "word list" which was reported by Roy-Campbell & Qorro, 1997). They observed that, in the reading comprehension tests they administered to secondary school students in Tanzania, students performed better when provided with a word list.

Implication
One indication in this section is that supplemental language support in Kiswahili may effectively facilitate student understanding of scientific concepts when the learning task is within the *zone of proximal development* of student, and that the language support is systematically to be withdrawn along with the students' development in English proficiency.

3.4 ICT in schools

It is generally acknowledge that ICT has tremendous impacts in many areas and contribute to the knowledge economy and human resource development. However, the same technology is now creating significant disparities known as the "digital divide" between developed and developing countries. In this section, a variety of arguments for ICT implementation in secondary schools in sub-Saharan African countries is described, and the significance of promoting ICT use amongst secondary school teachers is discussed.

3.4.1 Rationales and real practices of ICT use in schools

One of the rationales of promoting the use of ICT in schools is to take advantage of the potentials of ICT to support and enhance teaching learning practice in classroom. Particularly it is expected that ICT can enhance innovative classroom practices such as student-centred learning, activity-based learning, inquiry learning, collaborative learning and so on (e.g. Cox *et al*., 2004; Osborne & Hennessy, 2003; van den Berg *et al*., 2003; Tilya, 2003; Voogt, 2003).

With regard to science education, ICT is expected to play an important role to enhance and facilitate student learning. For example, *data logging systems* can support science experiments in data capturing, processing and interpretation and promote student understanding by quick data processing and visual data representation. C*omputer-based simulation* facilitates scientific investigation through a computerised representation of scientific phenomena. These ICT tools are expected to promote students' understanding of scientific theoretical knowledge and scientific methodology through investigative practical work. In addition, *generic computer software* such as word processor, spreadsheets, presentation and graphic software can also be used to support student learning in information processing and structuring (Cox *et al.,* 2004; Voogt, 2003).

However, studies in developed countries indicate that "*to use the potential of ICT is not easy and straightforward as was thought in the 80's*" (e.g. Voogt, 2002, p.47). For the majority of teachers to become able to make the best of the ICT for classroom teaching, "*they need significant time to develop their pedagogy as well as their ICT skills. Given the limitations on resources and the demands on teachers' time, this may be difficult to achieve in the foreseeable future*" (Cox *et al*., 2004, p.34).

3.4.2 Practical constraints in ICT implementation in developing countries

The literature shows several difficulties and constraints in ICT implementation in schools in developing countries. The implementation of ICT largely depends on the condition of infrastructures such as electricity supply, reasonable building and telephone line which are not always available in developing countries (Kozma, McGhee, Quellmalz, & Zalles, 2004). In terms of cost, the initial investment required to implement ICT is not small amount for schools. The cost is not only for purchasing the equipments, but they need to spend some money for maintaining the facilities (Osin, 1998). The school also has to deal with "*very real issues*" such as *security* for the precious equipments (Unwin, 2005) which is a very critical matter in developing countries. In addition, when considering the balance of cost and effectiveness, "*the target audience's motivation to use the computer and level of existing computer literacy should not be neglected*" (McKenney, 2001, p.37).

Kozma *et al*.(2004) report that, in evaluating ICT projects which aimed at enhancing ICT use in secondary schools in developing countries, several factors were indicated by teachers in the project schools as to why teachers did not make use of the ICT facilities available at their school. These factors include the "*lack*" of (i) ***time***, (ii) a congruent ***national policy***, (iii) adequate condition of ***telephone service*** (for the Internet), (iv) ***resources*** such as computers, software and reliable Internet connections, and (v) ***training and support*** to integrate ICT into the curriculum. It is noteworthy that many teachers claimed that they could not find time for computer activities because of overloaded ***curriculum*** and ***test requirements*** (ibid).

It should be noted that similar factors were also found as a problem in developed countries as well (e.g. Osborne & Hennessy, 2003). It indicates that, apart from the physical constraints, the current school curriculum and examination systems are other major obstacles for the "*full potential of ICT*" in both developed and developing countries (Voogt, 2003). It also suggests that, in both developed and developing countries, it is important to provide appropriate training and continuous support to teachers for effective use of ICT in schools.

Schools have to consider these factors before making a decision of ICT implementation in school, and it is not an easy task to make a distinction between "*doing things right*" and "*doing the right things*" (Tessmer & Harris, quoted in McKenney, 2001, p.48), especially when they are planning something new which they do not have much experiences in the practice. In one sense, physical implementation is not difficult as it is often the matter of money, but meaningful, appropriate and effective use of ICT in schools is really a challenging task.

Considering these factors involved in the ICT implementation, people cannot but wonder if it is really relevant and practical to implement ICT in secondary schools in sub-Saharan African countries such as Tanzania where the school may have a shortage of textbooks for students.

3.4.3 Significance and social demand of ICT implementation in schools

In spite of the several practical constraints in ICT implementation in the real school settings, there are still significance and rationales argued for the effort to implement ICT in schools in developing countries.

One argument for ICT implementation in schools may be found in the tremendous impact of *the Internet* and the *World Wide Web* in the rapidly developing information society. These powerful technologies enable students and teachers to access various information through the world-wide network, and communicate with other people around the world.

McFarlane & Sakellariou (2002) contend that, in the era of "*overloaded information society*", "*investigative critical science*" is an important element in science education to foster scientific literacy and scientific reasoning skills amongst students, and that ICT can play a central role to support such critical analysis skill development. These skills include "*an ability to **search** vast multimedia sources, **identify** and **interpret** relevant information, **critique** sources in terms of provenance, including source, accuracy, validity and reliability, **weigh** evidence which may be conflicting and, finally, **collect** and **synthesise** sources into an authentic representation of personal knowledge*" (McFarlane & Sakellariou, 2002, p.229).

The rationales of ICT implementation in schools are derived from not only educational significance but also socio-economical, political and cultural situations in which developing countries are now placed. As described in chapter 2, the governments of developing countries are very much concerned about the "*digital divide*" in the current rapidly growing global network, and they are eager to promote ICT implementation in schools so as not to be left behind in the knowledge economy (Kozma *et al*., 2004; Unwin, 2004; Zembylas & Vrasidas, 2005). A report of United Nations Development Programme describes "*The global gap between **have and have-nots**, between **know and know-nots**, is widening*" (quoted in Kozma, McGhee, Quellmalz, & Zalles, 2004, p.57). Since it was witnessed that increasing capacity of ICT has brought about further economic growth to the groups of "haves", the technological disparity is seen as one of the significant socio-economic and political concerns in developing countries.

With regard to political issues, it is discussed in the literature that globalization based on the use of ICT is expected to bring about an opportunity to promote democracy and prosperity in the world. "*ICT provide tools for disseminating information, participating in decision-making, and improving environmental conditions, gender equity, social justice, peace, and health*" (Lelliott *et al.* 2000, quoted in Zembylas & Vrasidas, 2005, p.66). The concern is that, without access to ICT, societies are in danger of further isolation and exclusion from the global development (Zembylas & Vrasidas, 2005).

In developing countries, there is also a cultural concern in the development of the global network. "*Developing countries are being invaded by foreign ideas and values that may undermine or overwhelm local cultural heritage and economic livelihood*" (MoCT, 2003, p.19). the governments of African countries are eager to promote human resource development in the field of ICT to cope with the development of ICT so that they can take advantage of ICT. The ICT policy paper of the Tanzanian government describes that ICT should convey "*locally relevant messages and information, providing opportunities for local people to interact and communicate with each other, expressing their own ideas, knowledge, heritage and culture in their own languages*" (MoCT, 2003, p.19). The ICT policy paper also expresses a concern about the negative side of the Internet citing the "*recent controversy on access to pornography via the Internet*" (MoCT, 2003, p.8) as moral and cultural harm for the youth.

Even though actual use of ICT may still be rather limited in many secondary schools in sub-Saharan African countries, considering these issues involved in ICT implementation in the context of the current global network society, there is little doubt that ICT is regarded as one of the important educational tools to be implemented in schools in developing countries (e.g. Kozma *et al*., 2004).

In order to promote ICT implementation in schools, teachers need to be equipped with the basic ICT skills to make use of the technology so that they will understand both the merits and constraints in the implementation of the technology. Thus, ICT literacy education for teachers in

both pre- and in-service teacher training is of great significance for this endeavour (Guttman, 2003; UNESCO, 2002; Unwin, 2004). The next section discusses practical ways of conducting ICT training for teachers as an in-service teacher training.

3.5 Practical hints for an in-service teacher training programme

In sub-Saharan African countries, a number of researches have been attempted in the provision of teacher professional development. The research findings as well as empirical and theoretical considerations in the literature were found to give practical guidance and hints to this study as to how an in-service intervention should be conducted in sub-Saharan African countries such as Tanzania. The following sub-sections describe some the practical hints learnt from the literature.

3.5.1 Practice-oriented training

In order for teachers to understand and assimilate a new idea or practical skill, teachers should have their own experience of doing the real tasks for themselves, rather than being lectured the idea, skills and jargons. Through the practical experiences of doing things, teachers may develop their own ideas as to how they can apply these ideas into their daily practices. Thijs (1999) contends, from her experiences of in-service programme in Botswana, that "*practice-oriented approach*" was a key element for an effective intervention practice. If teachers find a practical use of materials or an application of activities in the actual teaching practices, the possibility of their adoption of the practices will increase. This practical nature of programme seems to be an imperative condition for a successful intervention in any in-service training programme.

3.5.2 Flexibility of the programme

In the literature which describes the in-service interventions attempted in southern African countries, the significance of "*flexibility*" in the in-service programme is often emphasized (e.g. Motswiri, 2004; Ottevanger, 2001; Stronkhorst, 2001). In the context of developing countries where there are many uncertainties, the research programme needs to cope with the problem of uncertain situations in a flexible manner. Motswiri (2004) maintains that "*considering the challenging context of the developing world….., flexibility should also be the guiding principle in transferring and using knowledge, skills and resources from places where these intended changes have been attempted*" (p.65).

With regard to flexibility, a ***flexible timeframe*** seems to be an important consideration. The literature indicates that "*time problem*" of teachers was one of the constraints in the implementation of in-service interventions (e.g. Motswiri, 2004; Thijs, 1999). Although Chonjo *et al*. (1996) reported that many Tanzanian teachers were not overloaded in the secondary schools where they studied, teachers are usually busy for having many tasks such as setting and marking tests, preparation of practical experiments, and preparing and checking homework (e.g. Thijs, 1999).

3.5.3 Involvement of the whole school / head teacher

The role of the school head cannot be underestimated for any intervention practices in schools. A number of researches have concluded that active involvement and support of the school administration such as the school head and heads of department were indispensable for

effective and sustainable practice of in-service activities (e.g. Coppard, 2004; de Feiter *et al*., 1995; Thijs, 1999). Reflecting on an INSET project conducted in Tanzania, Coppard (2004, p.175) states:

> "*For a sustainable improvement of teaching and learning it would not be sufficient to focus on the capacity building of teachers only, but that it would be necessary to further develop the teaching environment through whole school development*."

In order to gain an active involvement of the school for research activities, an effort should be made to inform the school head as well as other teachers of any relevant information of the research so that intentions of the intervention are better understood by the school.

3.5.4 Motivation and level of tasks

Guskey (2002) contends that teachers' motivation is one of the critical elements for successful teacher professional development. As described before, some useful insights as to peoples' motivation are found in instructional theories such as *Keller's ARCS model* (Keller 1983; Keller & Suzuki, 2004). As have looked at before, when designing an in-service training, the four major conditions: "Attention, Relevance, Confidence and Satisfaction" are to be taken into account in order to increase and maintain participants' motivation towards the programme.

In relation to the learners' confidence and satisfaction, it is also of great importance to consider the participants' capability and the task level. Rogan and Grayson (cited in Rogan & Aldous, 2005) propose a notion of "*Zone of Feasible Innovation*" which they devised from an analogy of Vygotsky's *zone of proximal development* (Vygotsky, 1978). By the analogy, Rogan and Grayson contend that "*professional-development strategies are appropriate and useful when they proceed just ahead of current practice, but are within the zone of feasible innovation*." (Rogan & Aldous, 2005, p.335)

3.6 Summary – synthesis and implication

In this chapter attempts were made to learn from the literature, theoretical and empirical knowledge for several issues concerning this study. This last section summarizes the main findings and some insights gained in the literature review.

<u>*Problem analysis*</u>
A variety of problems are attributed to the students' poor performance in science and mathematics in sub-Saharan African countries. From the preliminary problem analysis, three key words: *motivation, visual representation and language support*, appeared to have relevance to this study. These key words seemed to have implications especially in the design of supplemental teaching/learning materials.

<u>*Three key notions and material design*</u>
As for motivation, there are four important conditions: *attention*, *relevance*, *confidence* and *satisfaction* which need to be taken into account to increase and maintain learners' motivation. In addition, there are several motivation strategies for each motivational condition. For example, attention strategy includes "interesting graphics or humour" which may raise students' curiosity and interest. These motivation strategies should be considered when designing materials.

With regard to visual representation, the design of materials may affect the learners' information processing, and the material design may facilitate learning process (or may hinder it). Visual representations such as diagrams and images can facilitate student learning by promoting information processing. Use of boldface or italic print is, for example, a useful way to promote learning process by evoking learners' attention. Additionally, when designing materials it should be aware of the role of visual representation in the gender bias.

The language of instruction has a significant influence on student learning. The language plays a critical role in human communication, and it is also an important tool for conceptualization for human being. In sub-Saharan African countries, the situation where students need to learn subjects in their second or third language in schools seems to be one of the causes of poor performance in science and mathematics. It is expected that, in Tanzania, supplemental teaching/learning materials with a language support in Kiswahili, applied depending on student linguistic level, will help student learning, especially in science and mathematics subjects which involve a number of abstract concepts and difficult terminology for students.

Roles and significance of ICT in secondary schools

Apart form the practical merit of using ICT tools for designing and making supplemental materials as intended in this study, ICT has a variety of potential roles to play in schools. Although ICT implementation in schools is not simple job, and it needs some careful considerations, there are still significances found in introducing ICT in secondary schools in Tanzania. It is expected that promoting teachers' use of ICT for making supplemental teaching/learning materials can be a kind of spring board for the teachers to become familiar with ICT.

Practical tips for an in-service training

With regard to an effective in-service training, the following four practical hints should be taken into account in the programme: (i) practice-oriented training, (ii) flexibility of the programme, (iii) school involvement and (iv) consideration on the participants' motivation and task level.

Since these theoretical and empirical considerations are just desk plans, they needed to be further explored in the real context, and there were several questions to be considered in the real school settings. For example, "*What ICT skill do teachers have at present?*" "*What ICT environment do the schools have in sub-Saharan African countries such as Tanzania*?" "*Do teachers have interest in using ICT in school*?" In order to investigate these practical questions, the field research was conducted in Tanzania. The study focused on the "validity" and "practicality" of ICT use by secondary school teachers for making supplemental teaching/learning materials. The field research consisted of mainly three components: (i) Context analysis, (ii) Material design and development and (iii) ICT training. The following chapters present the results and finding in the three components in Chapter 4, Chapter 5 and Chapter 6 respectively.

Chapter 4

Context Analysis

This Chapter presents the results and findings of context analysis conducted as a part of the field research in Tanzania. Section 4.1 gives a brief introduction. Section 4.2 illustrates the situations of two secondary schools where the research was carried out. Section 4.3 reports the results and preliminary analysis on a ***mathematics test****. The results of* ***biology test*** *are described in section 4.4, and the findings in a* ***student questionnaire*** *are described in section 4.5. Section 4.6 presents the outcomes in a* ***teacher questionnaire*** *conducted at the schools, and the findings in a* ***semi-structured interview*** *with head teachers are also described. The chapter ends with a brief summary in section 4.7.*

4.1 Introduction - aims of the analysis

In order to promote teachers' practice of using ICT tools for the sake of making supplemental teaching/learning materials, teachers need to be aware of (i) the necessity of providing supplemental support for secondary school students and (ii) what materials to be made with the ICT tools. In addition, for this study, it is important to know the current situation of ICT use amongst secondary school teachers as well as teachers' practice of making supplemental teaching/learning materials in schools. Context analysis was aimed to collect information with regard to these topics. For that purpose, five instruments were used in the analysis: (i) a mathematics test, (ii) a biology test, (iii) student questionnaires, (iv) teacher questionnaires and (v) semi-structured interview with head teachers.

The tests and student questionnaire were aimed to identifying problems amongst students in mathematics and biology which was expected to give guidance as to what supplemental teaching/learning materials should be developed using ICT tools in the study. It was also expected that sharing the students' problems with teachers would motivate them to create supplemental materials to support student learning. As for the tests, there was also an intention to contribute to improve student learning by giving feedback from the test results to both the school and participating students. The teacher questionnaire was administered to obtain preliminary information about teachers' practice of using ICT tools and also their experience and perception for making supplemental teaching/learning materials.

4.2 Context of the Two Secondary Schools

Before explaining the results of context analysis, in order to understand the conditions under which the research was conducted, situations of the two secondary schools at the time of the research are briefly described in this section.

4.2.1 Chang'ombe secondary school

General information

Chang'ombe secondary school is a government (community) O-level day secondary school. The school was belongs to a Teachers' Training College as its cooperative school, and located on the

campus of teachers' college in the town of Dar es Salaam. The school had about 480 students, both boys and girls. The classes were held in two sessions: morning and afternoon. In the results of Form 4 National Examination in 2004, the national rank of the school was 105 out of 802 schools.

Situation of ICT in school

There were eight desktop computers available at the school. All the computers were placed and used in the computer room. The computers were brought in the school by the Ministry of Education and Culture in 1999.The computers were rather an old model and the working capacity was very low. The hard disk size was only 212 MB and that of RAM was 16 MB. The CPU was 33 MHz, which was too slow to install a new operating system (OS) such as *Windows XP*. The OS installed in the computers was *Windows 95*. The word processing programme used in the computer was *Word 97*. The computers did not have the USB connection nor did the CD-ROM drive. Only a floppy disk drive was available. There were two Uninterruptible Power Supply (UPS) in the computer room, but one of them did not work. The electricity was sometimes suddenly cut out due to the over supply of electricity through the UPS device. The school had a scanner but due to the low capacity of the computers it could not be used in the school. The telephone line reached the school but there was no Internet connection. The computer room was equipped with air conditioners to keep cool inside the room. The students were asked to take off their shoes when they enter the room though teachers were allowed to enter with shoes. The room was cleaned every morning by cleaning staff.

Use of computers

The school was offering the students "*Computer Study*" as an optional subject. The computer classes were held in the computer room. Two computer teachers played a significant role in implementing computers in the school. They were originally ordinary subject teachers but after having enough experience in using computers, they became in charge of teaching the computer subject. They also gave computer lessons to teachers and taught basic computer skills. Although the computer class for students was held only a few times a week, students' development of the computer skills was impressive. Some of the students had already mastered basic skills of using computers, and could draw complicated diagrams using *MS-Word* and also made graphs using *MS-Excel*. Because no computer was specially assigned to the school secretaries, they were also using the computers in the computer room for administrative purposes. Other teachers were also allowed to use the computers. However it was observed that many teachers did not work with computers.

Printing environment

There were two printers in the computer room. Because there was no network in the computer room, when they wanted to print out a work they had to use a few computers which were connected to the printers. There was no photocopying machine in the school. The school did not have a duplicating machine[3] either. The school used to be able to use the digital duplicator[4] in the Teachers' Training College. After the equipment becoming unavailable in the college, the school came to depend on photocopy machines outside the school for duplicating printed materials such as test papers.

[3] Conventional duplicating machine, also called stencil duplicator, is a printing device which uses a stencil prepared beforehand with another device such as typewriter and duplicates the document rolling the drum on which the stencil is set.

[4] See a footnote on page 38.

Other contextual factors

Under the on-going education reform, the Teachers' Training College to which the secondary school belonged as the cooperative school, was changed to a part of the University of Dar es Salaam. In the process teachers and staff of the secondary school had to either remain in the school or leave to other schools. The Ministry's notice about the personnel changes was brought to the school during the research. The list of teachers who were to leave the school was released. As a result the school became in a sort of commotion. The teachers who were supposed to move out of the school became busy. Some participant teachers became loosing concentration on the ICT training in the research.

Photo 4. 1: Computer room in Chang'ombe Secondary school

4.2.2 Lugalo secondary school

General information

Lugalo secondary school is a (pure) government secondary school located in a regional town in the southern highland of the country. The school had a large number of students about 1,200 including both O- and A-level. The number of teachers was more than 70. The classes were held in two sessions: morning and afternoon. Academic performance of the school seemed to be as good as Chang'ombe secondary school. As for the Form 4 National Examination in 2004, the national rank of the school was 111 out of 802 schools. However the result of the Form 2 National Examination in 2004 was not good. Many Form 2 students failed the Examination in 2004 and were repeating again Form 2.

Situation of ICT in school

There was a computer room in the school. There were 13 old second hand computers in the computer room, of which 9 computers were working. The computers were brought in the school recently from the Ministry as well as from a church. The computers were the same type with the ones in Chang'ombe secondary schools. The hard disk size was 258 MB and the CPU was 33 MHz. The OS installed was *Windows 97*. The word processing programme was *MS Word 97*. The computers did not have the CD-ROM drive nor did the USB port. The school recently bought two new computers. The new computers were installed with the OS *Windows XP* and equipped with the CD-ROM drive. The new computers were connected to an ink jet printer.

Use of computers

All the computers including the new computers were placed and used in the computer room. The new computers were mainly used by school secretaries for administrative purposes. The school had not started offering the computer subject to students. Nobody was specifically

assigned to be in charge of teaching computer and maintaining the facilities in the school.

During the research, the school started the terminal examination. The tables in the computer room were taken to classrooms and all the old computers were set aside in the computer room. As a result, it was not possible to see the practical use of computers in the school. Many teachers said that access to the computers in the computer room was not convenient for them. The key of the computer room was kept by the secretary, and when she was not working in the room, the room was often closed.

Printing environment

There was a broken photocopy machine in the computer room, which had been out of order since a few months. The school was using a printing machine called *digital duplicator*[5] which can automatically print materials using stencil. But the digital duplicator was also broken down and the school failed to repair it. The school depended on copy machines outside the school for duplicating printed materials such as test papers. It was informed that the school had a plan to buy a new photocopy machine and a digital duplicator to improve the printing condition in the school.

Photo 4.1: Computer room in Lugalo secondary school
Old computers (left) and two new computers (right)

SESS project and the school

Lugalo secondary school was one of the project schools of Science Education for Secondary School (SESS) which is a project under the Ministry of Education & Culture to promote science education in secondary schools in Tanzania. There was a SESS regional technical officer in the school. In her office (a preparation room in the science laboratory) there was a desktop computer and a printer. The coordinator had a good skill and experience in using the computer. She made the SESS achievement tests with the computer for the project schools in the zone. The SESS coordinator kindly provided the SESS room for the ICT training in the research. Two old computers were moved from the computer room to the SESS room for the activities. The head teacher was a chairman of the head teachers of SESS project schools in the region. He was very positive to promote and encourage science (and mathematics) education in the school. He had strong administrative leadership in the school.

[5] Digital duplicator is a device, also called "*copyprinter*" or "*risographs*", which digitally captures an image from an original document and automatically creates a master of the image on the stencil from which it duplicates copies at a high speed.

Other contextual factors

A Teachers' Training College was located very close to the school. There were also private Universities in the town where they offered computer courses. There were some teachers in the secondary school who had learnt basic computer skills in such courses.

4.3 Mathematic test

Participants

A mathematic test was administered to Form 1 and Form 4 students. A total of 407 students participated in the test at the two schools (288 Form 1 students and 119 Form 4 students). The selection of the students was done situationally by the school. The students who were present in classrooms were asked to take the test. There was no intentional procedure taken for the selection.

Test questions and test

The test was consisted of 30 basic arithmetic calculations (Appendix A). The questions were prepared based on the results of former studies conducted at secondary schools in other regions in Tanzania (Sugiyama, 2003). The questions can be categorized into 8 groups of calculations as shown below (For the classification of the questions, see Appendix C).

(i) Addition / subtraction (miscellaneous basics) [e.g. 2 – 6 =, 7 + (- 2) =]
(ii) Addition for a negative number [e.g. - 6 + 3 = , - 2 + 5 =]
(iii) Subtraction for a negative number [e.g. - 6 – 3 = , - 3 – 5 =]
(iv) Subtraction for zero [e.g. 0 – 6 =, 0 – (- 4) =]
(v) Subtraction & use of brackets [e.g. - (4 – 7) =, - (8 – 3) =]
(vi) Subtraction & use of the small positive/negative signs[6] [e.g. - 9 - $^{+}$4 =, - 4 + $^{-}$2 =]
(vii) Multiplication / Division with a negative number(s) [e.g. 4 × (- 5) =, - 8 ÷ (- 2) =]
(viii) Order of calculations (BODMAS[7]) [e.g. 8 – 4 × 5 =, - 2 + 4 × 3 =, – (5 × 2) =]

The test was administrated without a strict time limitation. Most of the students finished the test within 20 minutes, however there were some students who needed more than half an hour to complete the test. It is worth noting that, amongst those slow students, there were few students who scored a higher mark, which indicates that they had understood the rules for the operations though they needed a longer time to calculate accurately.

Test result

The test results revealed that there were a number of O-level secondary students, including Form 4 students, who did not understand the basic arithmetic operations. The summary of the test result and a brief analysis on the results are shown in Appendix B and Appendix C. Figure 4.1 on the next page shows the score distribution of the result of Form 1 students. It should be noted that 22.6 % (65 out of 288 students) scored less than or equal to half marks (i.e. $0 < x \leq 15$), while 35.1% (101/288) scored more than 25 marks (i.e. $25 < x \leq 30$). The result indicates that there was a large difference in the student performance in the student population.

[6] In Tanzania, primary school mathematics textbooks use the small sign such as $^{+}4$ to distinguish the sign of positive and negative from the sign of operations (i.e. plus / minus)

[7] BODMAS is the abbreviation of "Bracket, Of, Division, Multiplication, Addition, Subtraction". It indicates the order of arithmetic operations.

Considering the fact that the test questions were basic arithmetic operations which are taught in primary schools, it should be taken very seriously that nearly a quarter of the Form 1 students scored less than half marks on the test. Those latent low achievers need special attention in the schools. Otherwise they will inevitably fail in understanding other topics in upper grade mathematics. Similar problems in the arithmetic operations were observed in secondary schools in other regions in Tanzania (Sugiyama, 2003), which indicates that the problem may be generally observed in many secondary schools in Tanzania.

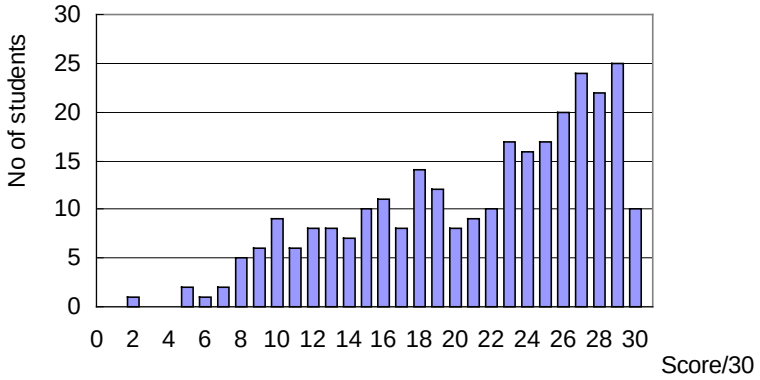


Figure 4. 1: Score distribution in the mathematics test (Form 1)

Preliminary analysis on the test results

Table 4.1 shows the ten questions which had a higher rate of mistake in Form 1 students. Nearly half of the Form 1 students made mistakes on some basic arithmetic calculations. For example, for the question No.14 [8 – 4 × 5 =] 48.6% of the students made mistakes, and the rate of mistake of the question No. 18 [0 – 6 =] was 41.7%. It should be noted that, even in Form 4, a considerable number of the students made mistakes on those questions.

*Table 4. 1: The list of the worst ten questions (% is the rate of **mistakes**)*

No	Question	Correct answer	Form 1	Form 4
8	$-9-{}^{+}4=$	– 13	49.7%	27.7%
14	8 – 4 × 5 =	– 12	48.6%	22.7%
25	– (4 – 7) =	3	47.6%	21.8%
23	– 3 – 5 =	– 8	44.8%	12.6%
13	– 2 – 8 =	– 10	43.8%	12.6%
18	0 – 6 =	– 6	41.7%	13.4%
2	– 6 – 3 =	– 9	40.6%	8.4%
28	– (5 × 2) =	– 10	37.8%	42.0%
29	– 2 + 4 × 3 =	10	37.8%	17.6%
12	– (8 – 3) =	– 5	37.5%	21.8%

It was observed that the type of questions to which many students made mistakes were mostly the same at the two secondary schools. While the questions to which many Form 1 students made a mistake were different from the ones to which Form 4 students made mistakes. It was noticed that, many Form 4 students (42%) made mistakes for the question No.28 [– (5 × 2) =], which was commonly observed in both secondary schools.

When the students' answers were sorted out according to the type of mistakes, it was found that many students gave the same wrong answer for a question, which indicates that they did not make the mistakes by chance. It can be assumed that they gave the wrong answer according to their misunderstanding of the rule of basic arithmetic operations. Focusing on the questions with a higher rate of mistakes found in Form 1 students, six types (A-E) of the questions were identified as more problematic in the test. Table 4.2 shows the type of questions and the most common wrong answers with the percentage of mistake. The questions of type A, B and C are concerning the operations involving subtractions of integers which could be effectively explained using the number line. Type D, E and F are related to the order of operations (i.e. BODMAS) which has little to do with the number line.

Table 4. 2: Types of common mistakes (Form 1)

No	Question	Correct answer	Total mistake rate	Most common wrong answers (Bold letters) (% of the students who gave the wrong answer)
Type A – Subtraction of a negative number (and variables)				
23	- 3 – 5 =	- 8	44.8%	**2** (23.6 %), - **2** (11.5 %), **8** (5.6 %)
13	- 2 – 8 =	- 10	43.8%	**6** (*25.3* %), - **6** (*8.0* %), **10** (*7.3* %)
2	- 6 – 3 =	- 9	40.6%	- **3** (33.0 %), **9** (4.2 %)
Type B – Subtraction of zero				
18	0 – 6 =	- 6	41.7%	**6** (22.9 %), **0** (*18.4* %)
9	0 – (- 4) =	4	36.8%	- **4** (*23.3* %), **0** (*12.5* %)
Type C - Subtraction and use of small positive/negative signs				
8	- 9 – $^{+}$ 4 =	- 13	49.7%	- **5** (*38.9%*), **13** (*4.5%*), **5** (*4.2%*)
20	4 – 7 =	11	34.0%	- **3** (20.5%), - **11** (8.7%), **3** (3.8%)
15	- 7 – $^{-}$ 5 =	- 2	30.9%	- **12** (14.2%), **2** (8.0%), **20** (6.9%)
Type D – BODMAS (Order of operations)				
14	8 – 4 × 5 =	- 12	48.6%	**20** (*26.7%*), **12** (*13.5%*)
29	- 2 + 4 × 3 =	10	37.8%	**6** (8.3 %), **18** (6.3 %), - **18** (4.9 %)
1	5 + 2 × 4 =	13	33.0%	**28** (26.7 %), **8** (2.8 %)
Type E – Subtraction & use of brackets (BODMAS)				
25	- (4 – 7) =	3	47.6%	- **11** (*24.0%*), - **3** (*12.5%*), **11** (*6.6%*)
12	- (8 – 3) =	- 5	37.5%	- **11** (26.0 %), **5** (5.6 %)
Type F – Multiplication & use of brackets (BODMAS)				
28	- (5 × 2) =	- 10	37.8%	**10** (*36.5* %)

From the preliminary analysis above, it was found that there were common patterns in students' mistakes on some questions and that students had wrong reasoning in their calculations. For example, for Type A questions, students seemed to have misunderstood that the negative sign before the first term was for the whole expression. That is, for the Question 2 [- 6 – 3 =], they firstly calculated 6 – 3 = 3, then added the minus sign to 3. [i.e. - 6 – 3 ⇒ - (6 – 3) = - 3]. Similarly, for the Question 23 [- 3 – 5 =], many students answered 2, probably because they calculated like - 3 – 5 ⇒ - (3 – 5) = - (– 2) = 2. (On the above calculations, the sign ⇒ indicates the step at which the students made the mistake.)

Another outstanding mistake was seen for Type F, Question 28 [- (5 × 2) =]. Many students, especially in Form 4 students, confused the distribution law of addition and that of multiplication, and they calculated as - (5 × 2) ⇒ - 5 × (- 2) = 10. In summary, the result of the mathematic test revealed that:

- *There were O-level secondary school students who did not understand the basic arithmetic operations, and there was a need to support those latent lower achievers in mathematics at the secondary schools.*

In this study, based on the analysis on students' mistakes in the test, a supplemental teaching/learning material was designed and developed to give explanation for the type of calculation which had a higher rate of mistakes (Appendix I). The *common mistakes* found in the analysis were used in the material to raise students' attention for their mistakes. When the test was retuned to students, the material was used to explain their mistakes.

4.4 Biology Test

Aim, participants and test questions

A Biology test was administered to Form 1 students in order to find out what problems Form 1 students might have in learning Biology, with the special interest in their understanding of basic scientific/biological concepts given in English. Totally 275 students took the test. As the mathematic test, the selection of the students was done by the school without any intentional procedure. The test consists of five multiple-choice questions which asked the students to choose the most appropriate Kiswahili description for scientific/biology terms given in English (Appendix D). Considering the proficiency of English language amongst the students, the test questions were prepared in Kiswahili. The questions were checked by Tanzanian teachers at the schools, and some questions were revised according to their corrections.

Test result

Table 4.3 shows the summary of the test result.

*Table 4. 3: The result of Biology test (Rate of the **correct answer**)*

	Terms asked in the Test	Lugalo sec. school	Chang'ombe sec. school
1	Observation	69.3 %	42.2 %
2	**Hypothesis**	***19.9 %***	**37.6 %**
3	Conclusion	49.4 %	65.1 %
4	Reproduction	56.0%	57.8 %
5	Infection	73.5 %	67.0 %

The term "Hypothesis" had the lowest correct answer rate at both schools. It should be noted that more than 40% of the Form 1 students did not understand the basic scientific terms such as "observation" or the basic biological term "reproduction".

Preliminary analysis on the test result

At both secondary schools, they were using the new *Provisional biology syllabus for secondary schools Form 1* (MoEC, 2005) which was recently provided by the Ministry. In the old syllabus (MoEC, 1996), the term "Hypothesis" was clearly mentioned in the topic of "Scientific process in Biology" in Form 1. But the new provisional syllabus describes only "Formulate scientific questions" without indicating "Hypothesis". So teachers might not have taught the term

"Hypothesis" explicitly to the Form 1 students. It could be one of the reasons why many students made mistakes in the question.

Another possible reason for the poor result on the "Hypothesis" was indicated, after the test, by some students as well as other teachers. According to them, the expression "nadharia tete" amongst the answer choices given for "Hypothesis" in the test [(b) Maelezo kwa nadharia tete.] was not a common expression to students though it was used to explain the meaning of the term in a dictionary.

The term "Infection" had a good result probably because the students had learnt the term "Infection" a short time before the test in a Biology lesson according to a teacher. Although the result of "Infection" was comparably better than that of other items, but still a quarter of the students made a mistake on the term.

The test results showed that many Form 1 students did not understand either the meaning of some of the English terms or the concept itself, which indicated that:

- *A remedial measure was to be taken to support student learning, especially for the lower grade students in terms of the basic scientific concepts.*

In the study, based on the results, a supplemental teaching/learning material was designed and developed on purpose to explain students "Scientific process in Biology" focusing on the meaning of "Hypothesis" and "Conclusion" (Appendix J).

4.5 Student Questionnaire

A Student Questionnaire was administered to Form 4 students in order to know students' perception toward science subjects particularly Biology. A total of 117 students responded to the questionnaire. The students were asked about their perception of the science subjects and the difficult topics in Biology which were taught in Form 1 and Form 2. The questionnaire included both close-ended and open-ended questions. As for the open-ended questions they were allowed to describe their opinions in either Kiswahili or English.

It was observed that there were similarities in the students' responses between the two secondary schools. In both schools, 60~70% of the students answered "*I like Biology as the best of the science subjects (physics, chemistry and biology).*" While a similar proportion of the students answered "*I dislike Physics*". Despite their preference to the subject of Biology, nearly 70 % of the students perceived "*Biology somehow difficult*". The Appendix E shows the questions and a summary of the responses.

Those students who answered "*Biology was (somehow) difficult*" gave mainly three types of reasons why it was difficult. They were (i) features of the subject contents, (ii) the language of instruction and terminology and (iii) problems pertained to teachers and the school.

With regard to the features of Biology which make the subject difficult, they described that:

- *Lina mambo mengi sana ya kusoma.* (There are many things to read / study.)
- *Linahitaji muda mwingi wa kusoma.* (It needs lot of time to study.)
- *Baadhi ya topic ni ndefu, vipengele nyingi.* (Some topics are long / have many subtopics.)
- *Noti zake kuwa nyingi.* (There are lots of notes to take.)
- *Michoro mengi.* (There are many drawings.)

Concerning the language of instruction many students described "*Studying Biology was (somehow) difficult*" because:

- *Baadhi ya topic zina tumia maneno na misamiati magumu.* (Some topics use difficult words and terminology.)
- *Lugha inayotumika katika somohili ni ngumu sana, lakini somo lenyewe sio ngumu.* (Language used is very difficult, but the subject itself is not difficult.)

Regarding the difficult topics in Biology taught in Form 1 and Form 2, many students listed up "Classification" and "Health and prevention of diseases". Other topics were "Nutrition in plants", "Gaseous exchange", "Respiration" and "Movement". The students were also asked to give the reasons why they perceived the topics difficult. Although reasons vary depending on the topic there were some common descriptions such as "*too many things to remember*", "*difficult scientific terms (names)*", and "*difficultly in understanding English*". Some students also blamed teachers' poor teaching when they were taught the topic.

It is noteworthy that some students contended that the topic was difficult to understand because their English proficiency was not good enough when they were taught it in Form 1 or Form 2. Some students described their problems as below.

- *Nilikuwa sijajua vizuri / sijafahamu lugha ya kiingereza.* (I had not known well / I had not understood English.)

One of the indications of the above results is that many students, especially the lower grade students, have difficulty in understanding some topics of Biology because of the language of instruction that is English.

From the results of the Student Questionnaire as well as the Biology test, it was assumed that:

- *Supplemental teaching/learning materials of Biology could support students learning, especially for the lower grade students, in terms of language such as difficult terminology, by offering the language support in Kiswahili along with the language of instruction; English.*

4.6 Teacher questionnaire and Head teacher interview

In order to collect information concerning the use of ICT amongst secondary school teachers, and also to know their experience and perception towards making supplemental teaching/learning materials, a teacher questionnaire (Appendix F) was administered at the two schools. A total of 62 teachers (32 females and 30 males) responded to the questionnaire. The general profile of the respondents is shown in the Appendix G. Although there was a wide range of respondents' age and teaching experiences, it was found that the teachers' population in the questionnaire was not extremely biased in terms of sex, age and their teaching experiences.

The questionnaire was composed of three components including both close-ended and open-ended questions. The first part was concerned with general information about teachers. The second part was about teachers' use of ICT focusing on computer, the Internet and electronic mail (e-mail). The third part was concerning teachers' practice of making and using supplemental teaching/learning materials. Teachers were also asked how to assist slow learners who do not understand basic concepts of mathematics such as arithmetic operations.

4.6.1 Teachers' use of ICT

From the questionnaire, it was found that eight teachers (13%) had a computer(s) at home. Although the percentage may not be high, it indicates that computers have surely and gradually been spreading into the Tanzanian society. Amongst the eight teachers there was a female teacher whose husband had a computer but she rarely used it by herself. About 30% of teachers answered that they used computers at least once a month, while about 40% of teachers had never used computers (Figure 4.2). If the numbers of teachers who answered "very rare" and "never used" are combined, nearly 70% of teachers did not practically use computer even though they were working in a school where they could have access to a computer.

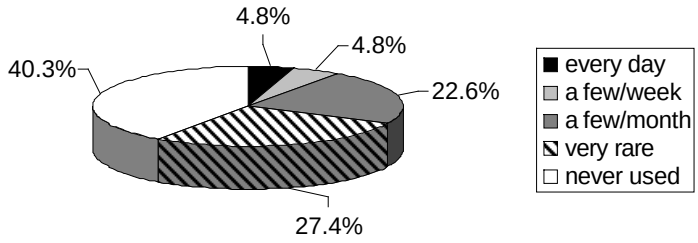


Figure 4. 2: Teacher's use of computer

When looked at the use of computers with regard to the teaching subject(s), as the Figure 4.3[8] shows, there was a large difference between *art subject teachers* and *science teachers*[9] in the schools.

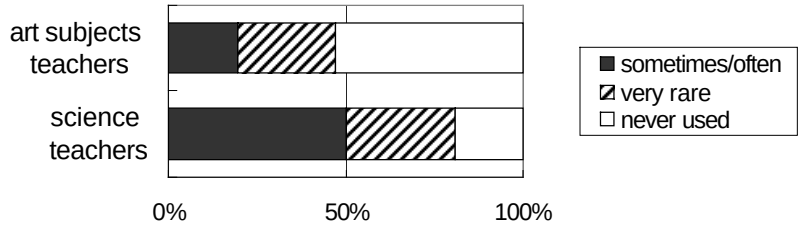


Figure 4. 3: Comparison of the use of computer between art & science teachers

The most of the respondents who answered to have experience of using computer replied "word processing programme" as their main use of computer software. Some of them also added some other conventional software such as "spread sheet" and "presentation software". A few also gave "publishing software". One gave "Computer Aided Design (CAD)".

The result may support the idea that, in order to enhance teachers' practice of using computer, particularly for those who have limited experience, the practical use of "word processing program" can be one of the relevant topics for the initial ICT training. One teacher included "computer games" in his response. As is often the case amongst children and even in adults as well, computer games can be a good starting point for teachers to become familiar with computers though it may not be officially acceptable in a real school setting.

[8] In the Figure 4.3, "sometimes/often" includes all the "a few times a month", "a few times a week" and "almost every day".

[9] In this analysis "*Science subjects*" include mathematics, physics, chemistry, biology, agriculture and computer science. All the other subjects are included in "*Art subjects*".

When asked to evaluate their computer skills, as Figure 4.4 shows, the result became rather similar to that of the frequency of using computers shown in the Figure 4.2. It indicates that teachers' confidence in the use of computer increases according to the frequency of their use of the computers.

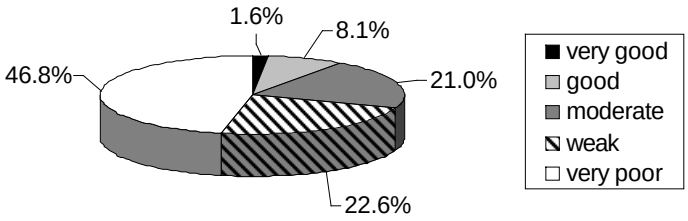


Figure 4. 4: Teachers' evaluation of their computer skills

With regard to the use of the Internet, it was found that 40 teachers (65%) had never used it, while 10 teachers (24 %) answered that they used it regularly at least a few times a month (Figure 4.5). There were teachers who had experience of using the computer but never used the Internet. While there was a female elder teacher who answered not to have any experience of using the computer but had experience of using the Internet, saying that she sometime went to an Internet café with her son who used the Internet for her.

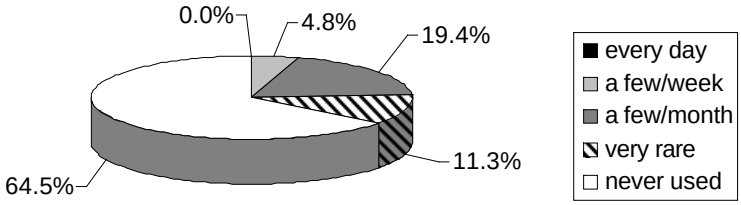


Figure 4. 5: Teachers' use of the Internet

Regarding the use of e-mail, the result became almost the same with that of the use of the Internet. It was also learnt from informal conversation with some teachers, that one of the main reasons for them to go to the Internet café was to use e-mail.

In Tanzania, having access to the Internet at home is rather expensive for most of the teachers. It costs around 20 ~ 40 euros per month which is nearly half of the teachers' monthly salary. The eight teachers who answered to have a computer(s) at home were also found not to have their computer connected to the Internet at home. When teachers use e-mail, they usually go to an Internet café and use a free e-mail account. One young teacher said "*I do not know very well how to use the computer but I know how to use e-mail*".

4.6.2 Teachers' practice of making/using supplemental teaching/learning materials

As the third part of the Teacher questionnaire, teachers' practice of making and using supplemental teaching / learning materials was preliminary investigated.

Making and using teaching aids

When asked how often they used extra teaching / learning materials including various types of teaching aids, as much as 21% of the teachers responded that they used a teaching aid in almost

every lesson (Figure 4.6). If "often" and "sometimes" are added to the "every lesson", more than 95% of the teachers answered that they frequently used a teaching aid(s) in their lesson. Only 3% of the teachers replied that they rarely used teaching aids.

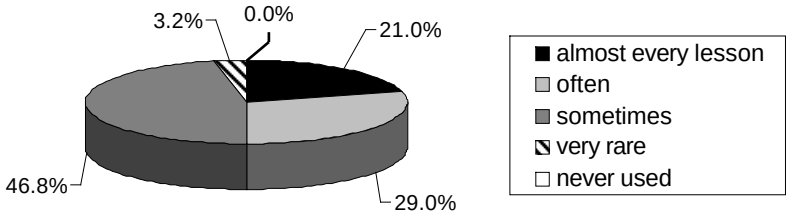


Figure 4. 6: Use of teaching aids

However, the result may lead an overestimation for the teachers' practice of using teaching aids. It is generally perceived that teachers should make use of a teaching aid in lessons as much as possible. It is therefore assumed that teachers tend to over emphasize the use of teaching aids in their class.

When asked about handouts (printed materials) as a kind of teaching aids, 29 teachers (46.8%) answered that they had made handouts by themselves to give students for lessons. Amongst the 29 teachers, 21 teachers (72%) answered that they made the handouts with handwriting and then made the copies for distribution. Five teachers (17%) made the materials with using computer. Two teachers (6.8%) used typewriter. One teacher answered that he made a draft and asked secretary to type the handout (Figure 4.7). From the result it can be said that it was still not common practice for many teachers to use computer to make handouts in the schools.

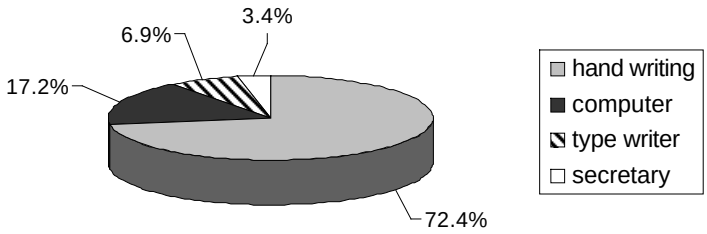


Figure 4. 7: How to make handouts

Regarding the methods of duplicating handouts, only 3 out of the 29 teachers used a conventional stencil duplicating machine which has been and is still a common duplicating device in many secondary schools in Tanzania. It is notable that 21 teachers (72%) used photocopying machine in shop outside the school (Figure 4.8).

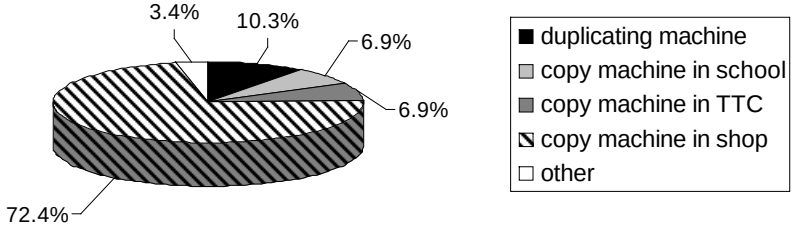


Figure 4. 8: How to make the copies of handouts for distribution

When included all the responses of photocopying machine "in the secondary school", "in the teachers' training college" and "outside the school", almost 90% of the teachers used a photocopying machine for duplicating the materials. The result may reflect the fact that photocopy-shops are now commonly seen in towns in Tanzania. It also indicates that teachers, or the school as a whole, now commonly use the available commercial service which costs little bit higher but offers a better quality of work, compared with the conventional duplicating machine in school which costs less but of which quality of duplication may not be good.

Problems and constraints for the practice

Although teachers in general agree that supplemental teaching/learning materials can be helpful to support student learning, many teachers do not make such materials frequently in school in practice. An open-ended question was given to the teachers in order to know their perception towards the practice of making materials, especially constraints and problems they may encounter in making materials in school. Responding to the question, a teacher described:

> "*Teachers have a lot to do yet they are underpaid. Making such things is out of their mind. It will cost their time. They have to buy stationary at their own cost as the school does not provide enough materials.*"

Teachers argued mainly two types of problems or constraints in the practice of making supplemental teaching/learning materials in school. One type of problems pertains to the condition of school and the other is concerned with teachers.

As the school related problems, many teachers listed up the financial problems of the school which include the following:

- Lack of fund to buy stationary or for photocopying (11x)
- Lack of facility and resources (i.e. computer, photocopy machine) (7x)
- Inadequate financial support for teachers. (i.e. Teachers have to buy materials such as papers for preparing teaching/learning materials.) (13x)

Some teachers contended that problems existed in the administration of the school. Teachers pointed out problems including the following.

- Poor support and lack of cooperation of the administration (4x).
- Procedural constraints or bureaucracy in the school to make a material printed (e.g. difficulty in asking the secretary to type the materials) (2x).
- No or limited access to computers (2x).

With regard to the problems concerned with teachers, they cited problems in working condition of teachers such as:

- Lack of *motivation / incentive* for teachers (e.g. low salaries) (13x)
- Lack of *time* for making materials (e.g. too much extra duties) (16x)
- Lack of *teaching materials or resources* (e.g. reference book for teachers) (11x)

They also pointed out some problems pertained to teachers' skill and knowledge, which include:

- Lack of *basic computer knowledge* (11x)
- Lack of *creativity* to make use of materials available (3x)
- Lack of *competence in designing* materials (1x)
- Lack of *initiative* from teachers (1x)

One teacher also indicated a problem amongst the students, saying that "*O-level students do not make use of such learning materials effectively, which discourages teachers to make the materials*." Other teachers also agreed to this comment. However the comment implies several issues and it needs further discussions about how to make effective materials and how to use the materials effectively so that students can make the best of the materials prepared by teachers.

As for the *time* for preparing the supplemental teaching/learning materials, 54 teachers (87%) answered that "*they can find time*" in Question 19, though in Question 18, 16 teachers (25.8%) mentioned "*the lack of time*" as a reason why teachers do not make such materials. This may reflect the teachers' ambivalent feeling toward the practice of making supplemental teaching/learning materials. That is, they understood the importance of materials and they felt they should find time to make supplemental teaching/materials. However, in practice, they do not make the materials and they tend to find an excuse for not doing the practice mentioning several problems or constraints including the lack of time.

It was found, from the teacher questionnaire, the semi-structured interview conducted to participant teachers in the ICT training and informal conversation with teachers, that three conditions were perceived by the teachers as the major problems or constraints which hinder the teachers' practice of using ICT for making supplemental teaching/learning materials at the secondary schools. These conditions are (i) poor printing conditions such as lack of photocopying machine and unreliable supply of the stationary, (ii) hindrance of administrative procedures to use computers and for duplication of the materials. (iii) teachers' problems which include lack of knowledge and skills of ICT tools, lack of creativity, lack of resources and lack of motivation.

4.6.3. Head teachers' view towards the practice

At the end of the research at each school a semi-structured interview was conducted to the head teacher in order to know their opinions about teachers' practice of using ICT tools for making supplemental teaching/learning materials in the school. The interview schemes were prepared with the reflection on the result of the teacher questionnaire. The followings are the main points of the interview questions.

- Significance of supplemental teaching/learning materials
- Problems and constraints for the practice
  (i) Printing condition, (ii) Administrative issues, (iii) Access to the computers
- How to support and enhance teachers' practice

Firstly both head teachers expressed their surprise at the test results with the high rate of mistakes in the basic questions. They admitted that a remedial measure should be taken to support the latent low achievers. They appreciated the ideas of making supplemental teaching/learning materials as one of such remedial supports. They also acknowledged the design intentions of the handouts developed in the study, including the use of Kiswahili as a language support.

When asked about the use of ICT, the head teachers agreed that ICT tools like computers should be used more effectively in the schools. Both head teachers said that they were making efforts to improve the ICT environment in the schools. They disclosed that they had a plan to purchase a few new computers and a photocopy machine near future.

Regarding problems in the practical use of ICT in the school, the head teachers claimed that

financial constraints such as the lack of new computers and photocopy machine, and the lack of fund for the Internet connection are the major problems to be overcome. They also argued that teachers in general did not have enough knowledge and skills of ICT, and that teachers were also busy for their own activities.

When asked about the problems of printing conditions in the school such as shortage of stationary for duplicating materials as pointed out by teachers, both head teachers agreed that the lack of appropriate equipments such as computer and photocopy machine was the problem, but they maintain that the stationary was not the essential problem. They said, if the quality of materials created by teachers is good enough, and if there is real necessity to duplicate the materials, they do not refuse duplication of the materials but rather support the practice even trying to find available stationary.

The head teachers also contended that there was a necessity of administrative control on the printing procedure. They said, if a teacher makes good material with the intention of supporting student learning "*in the school*", the teacher should show it to either the head teacher or the academic master to get approval for the duplication. They added that this seemingly bureaucratic measure is necessary because otherwise there are some teachers who make copies of some individual materials for their own purpose. They showed a concern that teachers might copy some materials not for the students of the school but for their individual tuitions they conduct "*outside the school*". According to them, teachers tend to complain about shortage of stationary because they usually directly go to the school secretary to print some materials without asking the permission from the administrative office. Teachers are often told by the secretary that there is not enough stationary in the school. A head teacher added, "*It is true that finding the stationary for duplicating materials is sometimes difficult in the school, however, if a teacher makes good and useful material, students themselves may contribute a small amount of money for the stationary.*"

When asked how to support and enhance teachers' practice of using ICT, the head teachers agreed that it is important for the teachers to make practice of using computers as often as possible so that they become familiar with the modern equipment. However when it comes to putting computer(s) in a place where teachers can easily access to a computer, rather than the computer room, they contended that there was always the security problem in the school, and showed reluctance to replace a computer(s) from the computer room to a separated place such as a department room. In addition a head teacher claimed that there was a problem of "*individualism*" amongst teachers. He said, because teachers tend to use computer for individual purposes, it would be difficult to assure proper use of computers if the computers were placed in different places.

4.7 Summary

In an effort to understand the context of the study, the context analysis was carried out. The analysis was mainly aimed to find out (i) the current ICT situation at the schools, (ii) problems amongst students in mathematics and biology as the targets for making supplemental teaching/learning materials, (iii) the current teachers' experience of using ICT and (iv) teachers' practice of making and using supplemental teaching/learning materials at the schools. Some of the findings in this chapter are summarized below.

ICT situation at the schools

- The schools had old computers in the computer room.
- The computers had only floppy disk drive but not CD-ROM drive.
- There was no access to the Internet at the schools.
- The schools did not have photocopy machine and depended on a photo-copy shop outside the school.

Tests and students questionnaire

- There were a significant number of students, particularly in Form 1, who made a mistake in basic arithmetic operations. From their mistakes, some common mistakes were identified.
- Many Form 1 students did not understand the meaning of basic scientific terms such as "hypothesis" and "conclusion".
- Students perceived biology somewhat difficulty. One of the reasons was difficult English terminology in the subject.

Teacher questionnaire and head teacher interview

- Teachers had a limited experience and skill of using ICT even though they were working in a school where they had access to a computer.
- Making supplemental teaching/learning materials using computer was not common practice for most of the teachers.
- Several constraints were perceived by teachers for effective us of ICT at the schools. They include physical problems such as lack of computers, stationary and conducive printing environment, and administrative bureaucratic procedures for printing materials and the use of computers. As for these problems, there was a gap observed between teachers' views and the head teacher' opinions.

On reflecting the findings in the context analysis, two other research activities were attempted in the study. Firstly based on the test results, supplemental teaching/learning materials were designed and developed for mathematics and biology. Secondary ICT training was conducted for science and mathematics teachers at the schools. The following two chapters describe the two activities respectively.

Chapter 5

Material design and development

Based on the three key words; motivation, visual representation and language support described in chapter 3, and the results obtained in the context analysis explained in chapter 4, a handout of mathematics and a biology material were designed and developed as an example of supplemental teaching/learning materials. This chapter explains ideas, intentions and attempts on material development in the study. Section 5.1 describes ideas and intention of material development. Section 5.2 reviews design features of the materials. Section 5.3 illustrates actual attempts made in the material design and development in the study.

5.1 Ideas and intentions of material development

As described in chapter 1, the original motive of this study was to explore a way of supporting student learning in science and mathematics in the O-level secondary schools in Tanzania, especially those who have difficulty in understanding basic scientific concepts due to their poor basis in the subjects and low English proficiency.

From the problem analysis in the literature review, three key words; *motivation*, *visual representation* and *language support*, were identified as the relevant design features of the supplemental teaching/learning materials in this study. The supplemental materials are expected to play a role to support student learning not only by supplementing learning materials but also by offering learner-friendly explanations with visual representations as well as some language support which is not offered in the conventional school textbooks. The materials are also aimed to work on the cognitive and affective aspects of student learning and motivate them to learn science subjects. Such materials are to be prepared depending on the level of students to facilitate student understanding of basic science concepts such as arithmetic operations. Although supplemental teaching/learning materials by themselves may not directly contribute to improve teachers' instruction in classroom, it can also be expected that the materials can play a role to enhance conventional teaching practice in classroom, which is an important element to improve student performance.

Apart from the potential role of the materials to support student learning, there was another practical role for the material development in the study. One of the important components of the research was to conduct ICT training for secondary school teachers to observe their ICT skills and experience, the ICT training was intended to introduce some basic computer skills to create visual appealing supplemental teaching/learning materials by teachers (a detailed description of the ICT training is given in the next chapter). Therefore there was a necessity to develop a prototype of the material to use in the ICT training as an example of the task goal of the training.

Based on the findings in the context analysis described in the last chapter, handouts for the "arithmetic operations" and "scientific process in Biology" were designed by the researcher. The contents and the format of the materials were checked by Tanzanian subject experts as well as a few participating teachers, and the materials were revised. The final versions of the materials were produced at the end of the research activities. The supplemental materials made in the study are attached in Appendix I and J.

5.2 Material design features

As described above, this study adopted the following three key concepts as the design features of the supplemental teaching/learning materials; (i) Motivational design, (ii) Visual representation and (iii) Language support in Kiswahili. The following sub-sections briefly describe how the study attempted to realized the design features in the materials.

5.2.1 Motivational design

Several motivation strategies could have been applied in the design of the supplemental teaching/learning materials. In this study, it was intended to realize motivation elements in the materials according to the ARCS model which was described in the chapter 3. To gain students' *attention*, a problem statement such as "*Many students make mistakes in the questions below…*"was described at the top of the materials so that students became aware of what problems were to be learnt in the materials (See Figure 5.1 on the next page, or Appendix J). As another attention strategy, *humorous cartoons* were incorporated in the materials in order to stimulate students' curiosity. The cartoons were designed to be *gender neutral* and callouts were used to give important notices or humorous statements, which were also expected to raise students' attention.

As the second component of ARCS model, the "*relevance*" strategy to increase students' motivation was attempted, for example, by choosing appropriate and important topics for the students, which was determined from the results of the context research as described in the chapter 4.

Although it is not easy to attain all the elements of motivation strategies in a printed material, the third and forth components of ARCS model: "*confidence*" and "*satisfaction*" were also considered in the design of materials by giving, for example, relevant exercises in it. The volume of the task was considered not to be overloaded for the target students taking into account students' satisfaction for the task.

5.2.2 Visual representation

In order to make the materials visually appealing, simplified diagrams such as the number line with cartoons were used to compensate some parts of the explanations, which were expected to promote student understanding of calculation process and scientific concepts.

An attempt was made, especially in the mathematics handout, to reduce the textual information and increase the visual representation for the explanation of concepts (i.e. process of the arithmetic operations). The use of textboxes and callouts was expected to make the materials more visually understandable. Although the layout of the materials was pointed out by experts as an important element for an effective visual material, it was not systematically considered in the design process in the study.

5.2.3 Language support

As the language support, Kiswahili was used in the materials to facilitate student learning as well as to motivate them to learn the topics with the materials. It should be noted that materials were not supposed to give all the explanation in Kiswahili but they should offer language scaffolding to enhance both student learning of subject contents and English language

acquisition. The degree of language scaffolding was to be transitionally reduced as the students' level of English proficiency increases.

5.3 Development of the materials

5.3.1 Mathematic handout

Based on the analysis on students' mistakes in the mathematics test, a mathematics handout was designed and developed (Appendix I). The *common mistakes* found in the mathematics test were used in the material in order to raise students' attention towards their mistakes. Figure 5.1 shows a part of the mathematics handout developed in the study. A diagram of the number line together with the illustration of cartoons' movement was expected to support students' understanding of the concept of arithmetic operations by means of action.

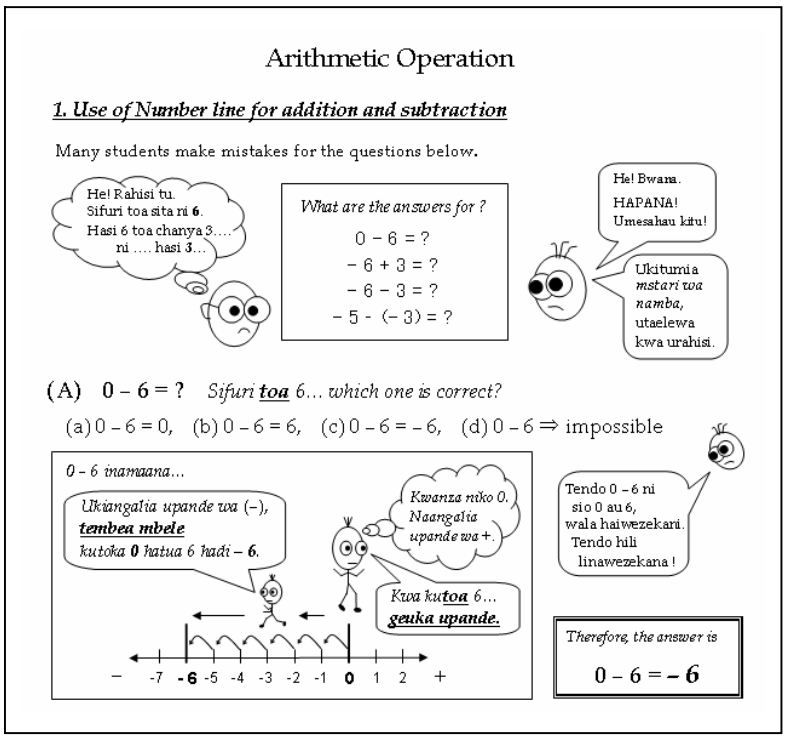


Figure 5. 1: A part of mathematic handout made in the study

As described above, cartoons were incorporated in the material with the intention to realize the motivational design. Because this handout was intended to use for Form 1 students especially those who had poor basic knowledge and low English proficiency, Kiswahili was used in many parts, which was expected to promote students' understanding as well as to motivate them firstly to read the material and then to think the concepts by themselves.

5.3.2 Biology handout

Biology handout was also designed based on the findings in the context analysis. Considering the problems found in the biology test as well as the student questionnaire, the topic of the material was chosen to give explanation of "Scientific process in Biology" with a special focus on the meaning of "Hypothesis" and "Conclusion" (Appendix J).

As the mathematics handout, simplified diagrams (the field and plants) were incorporated to facilitate students' mental model development for the scientific concept. In addition, humorous cartoons, callouts and textboxes were used as the motivational and visual elements in the materials. Contrary to the mathematics handout, many English texts were used in the biology handout. Although it was not intentional decision, when considering the balance between English and Kiswahili, it resulted in an English dominant material. As for this language balance, no further research was carried out to observe students' response and its effect on student learning.

5.3.3 Informal evaluation of the materials

In order to support and improve student learning, the quality and didactical aspects of the materials are of great importance. However due to the preliminary nature of the study, the impact and effectiveness of the materials were not systematically explored in the study.

When the tests were returned to the students, the materials were distributed to the students and used to explain the common mistakes found in the tests. It was observed that students perceived the design of the materials positively, and they enjoyed the illustrations and cartoons in the materials. Teachers also evaluated the design and contents of the materials positively.

Chapter 6

ICT training

ICT tools such as computer and the Internet were expected to be of great help for teachers to create supplemental teaching/learning materials. With a computer, it becomes easy to produce and reproduce materials and distribute them to students. In addition, with ICT, teachers can make use of digital images and make the materials visually appealing. As the third component of the field research, ICT training was conducted at the two secondary schools to explore the practical use of ICT tools by teachers for making supplemental materials. As an introduction, the aim, goals and programme features are described in section 6.1. Section 6.2 gives an outline of the training programme and also describes the findings in the training. The participants evaluations and reflections on the programme are described in section 6.3.

6.1 Introduction

6.1.1 Aims of the training and the programme design

The context research revealed the situation of ICT use amongst secondary school teachers. Although ICT tools such as computers and the Internet were not commonly used by many teachers at the schools, there were teachers who had some experience of using computers. In order to explore the practical use of ICT by teachers, especially the use of computer and the Internet, ICT training was conducted to selected science and mathematics teachers at the schools. It was aimed, through the training activities, to observe teachers' practice, interest and difficulty in using ICT tools, and to gain insight as to how ICT can facilitate teachers' practice of making supplemental teaching/learning materials in secondary schools. It also aimed to contribute to increase teachers' skill and knowledge of ICT as a part of teacher professional development.

Based on the finding in the literature review, the training was carried out having the following four practical hints in mind: (i) practice-oriented training, (ii) flexible timeframe, (iii) involvement of school administration, and (iv) consideration of teachers' motivation and the task level

6.1.2 Goals and tasks of training

The training programme was designed to promote teachers' practice of using ICT tools, focusing on how to create and use diagrams and digital images with word processing programme to make visually appealing supplemental materials. Based on the results of the context analysis, a tentative goal of the training was set to develop supplemental teaching/ learning materials to deal with the problems found in both mathematics and biology tests.

As was considered in the design of supplemental teaching/learning materials, the training programme was designed taking teachers' motivation into account. Tasks contents were determined to make the training more authentic and practice-oriented. Focus of the training was on the use of word processing programme, especially using tools in the programme to make drawings, which seemed to be relevant to their ICT skill and their interest.

6.1.3 Activity guide

As a training manual, an "Activity guide" was prepared by the researcher. The guide was designed with the intentions of (i) introducing the participating teachers several practical and useful techniques of using word processing programme; *Microsoft Word* (*MS Word*), (ii) giving them several exercises for practicing the skills learnt in the training, (iii) guiding them how to make supplemental teaching/learning materials by showing examples of some components of the intended materials. The activity guide was designed having the following three basic design principles in mind which were derived from instructional theories and empirical studies on the instructional manuals: (i) task-oriented approach, (ii) brief instruction and (iii) visual instruction with the use of screen captures

The activity guide was also intended to give the participants authentic, realistic and meaningful tasks as quickly as possible so that they could have "*an immediate opportunity*" to work the tasks (van der Meij & Carroll, 1995). The guide provided the participants with a brief instruction to let them carry out their tasks with their own initiative and responsibility filling in the gaps in the instruction by themselves, which was expected to enhance participant's active role in the knowledge construction (ibid). The activity guide was incorporated with a number of full and partial screen captures in order to facilitate participants' development of mental model on the tasks (Gellevij & van der Meij, 2004). It also applied *fading technique* to gradually reduce the procedural support for tasks in order to stimulate participants' learning process (ibid).

A prototype of the activity guide was developed while the researcher worked at the first secondary school. It was unfortunate that the participating teachers could not go through all the planned activities at the first school due to several constraints. For the second school, the activity guide was revised and the training programme was modified accordingly.

6.2 Training programme

6.2.1 Participants

Totally ten science and mathematics teachers (5 females and 5 males) participated in the training. Six teachers attended in Chang'ombe secondary school and four teachers in Lugalo secondary school. All the teachers were diploma teachers.

The participants were purposely selected from the science and mathematics departments. Originally it was expected to have participants who already had some experience of using computers. However in Chang'ombe secondary school there were a few participants who had very limited computer skills. While in Lugalo secondary school all the participating teachers already had certain experience and skills in using computers including basic word processing.
Two of the participants were recently graduated from Dar es Salaam Teachers' Training College where they learnt basic use of computers as a part of the curriculum. Therefore they possessed basic knowledge and skills in file management and the use of the word processing programmes. Profiles of Participating teachers are shown in the Appendix H.

6.2.2 Programme

The training was focused on practical use of the computer, especially the use of *MS Word* for making visually appealing supplemental teaching/learning materials. In each school the training was conducted within one week (five working days). The training was held at the

computer room at Chang'ombe secondary school and at the SESS room in the case of Lugalo secondary school. Table 6.1 shows the contents of the training programme.

Table 6. 1: ICT training Program

Day	Title	Activity
1	File management	● Create and save a new Word file ● Create and save a Word file in Floppy diskette ● Formatting letters
	Making tables with MS word	● Make an Arithmetic Drill Sheet ● Make an Arithmetic Quiz ● Make a Table for an experiment
2	Drawing diagrams with MS word	● Draw a figure ● Text box ● *AutoShapes* ● Draw a Number line ● Use of the *WordArt*
3	Use of digital images	● Copy and paste the images ● Use of digital resources for making teaching/learning materials
4	Use of the Internet	● Search for information on the Internet ● Search for images and the Web ● Save and use images for making teaching/learning materials
5	Use of digital camera and scanner	● Capture images with a scanner ● Take photos of science / mate apparatus ● Use the images/photos for making teaching/learning materials

The training programme consisted of six sessions. In each session, several tasks and exercises were given to the participants. Each participant worked on computer individually to carry out the tasks. During the session the researcher gave instructions, support and advice to the teachers and also observed their computer skills. The work of each teacher was saved in an individual floppy diskette. The training schedule was flexibly arranged according to the participants' schedule at the school. Usually the researcher worked with a few teachers at a time. One session was usually held for about one or two hours. Sometimes participants continued working up to three hours.

6.2.3 Teachers' skills and experiences in using ICT tools

All the teachers took an interest in the ICT training and were highly motivated to take part in the programme. Activities of each session and observed teachers' skills and experiences are briefly described below.

Basic skills and File management

As explained above, there were a few teachers who took part in the training with very limited skills in using computers. These teachers had still difficulty in double clicking on the mouse. Some teachers had problems in file management and were sometimes at a loss about what to do to save a file and to find it again to work on it.

Making tables with MS word

It was observed that making tables with *MS Word* was not difficult for most of the participants. They had experience of making tables with the software though some of them had forgotten how to do it.

Drawing diagrams with MS word

It was found that most of the participant teachers had limited or no experience of drawing diagrams using "*drawing tools*" of the word processing programme. The drawing activities were a little bit difficult for some teachers partly because of teachers' poor skill in the use of the mouse and partly because of the bad mechanical function of the old mouse. However the teachers enjoyed drawing and very much motivated to work on computers for the activities. The Figure 6.1 below show a few works made by teachers.

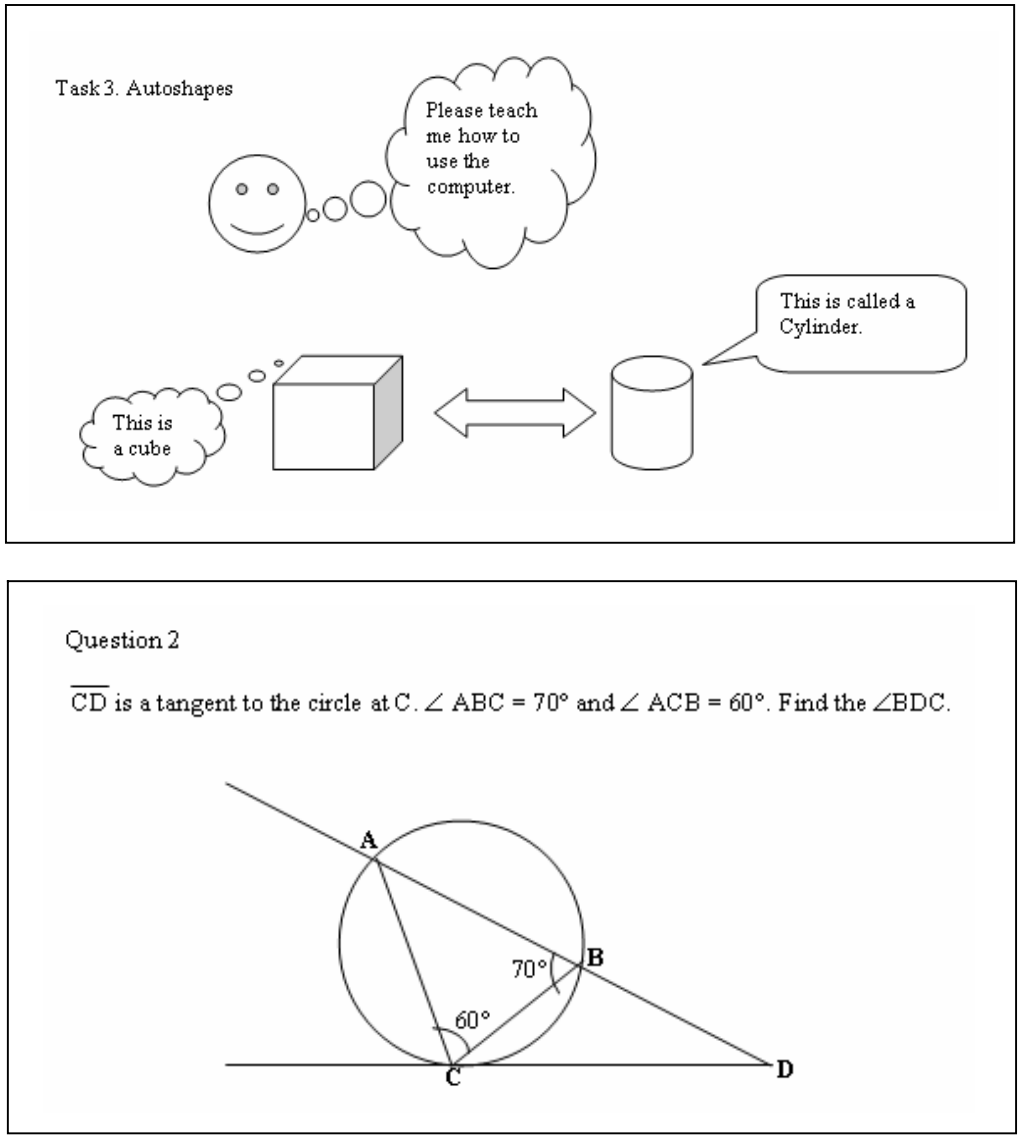


Figure 6. 1: Teachers' works of drawing diagrams with MS word

Use of digital images

Digital images such as photos of Nelson Mandela, plant and frog, and diagrams and cartoons were prepared by the researcher beforehand and provided with a floppy diskette. Handling images by copying and pasting was not a difficult task but it was a new experience for most of the participants. The participant teachers enjoyed making drawings using digital images (Figure 6.2).

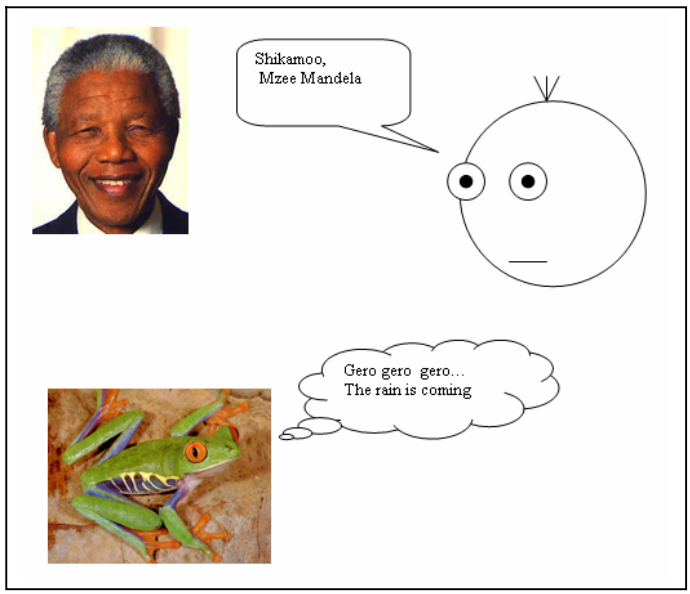


Figure 6. 2: Teacher's work of using digital images

Use of the Internet

Some teachers took part in the introductory training for the Internet. Since the schools did not have access to the Internet, the session was conducted at the neighbouring Teachers' Training College in the case of Chang'ombe secondary school and at an Internet café in town as for Lugalo secondary school. Teachers were asked to look for interesting and useful images using Web search engines for making supplemental teaching/learning materials in mathematics and science. They also looked for Web sites to obtain useful information for their teaching subjects. Two teachers had never used the Internet. However they quickly understood how to do the Web search and found interesting images and Web sites. They downloaded some of the images and Web contents and saved them in floppy diskettes. After the activities using the Internet, the saved files were looked at with the computers at schools. Some digital photos were not able to properly deal with the computers at the school due to the low working capacity of the computers.

Use of digital camera and scanner

In Lugalo secondary school, a scanner and a digital camera were also introductorily used to obtain digital images. The researcher firstly showed them how to scan photos and diagrams with scanner. Then using the digital camera, teachers took photos of several teaching aids and apparatuses in the science and mathematic department. Although they could not properly deals with these digital images with old school computers, they could see these images with the computer belonging to the SESS office which had a better capacity. It was suggested by teachers that digital images produced by scanner and digital camera could be used to make supplemental teaching/learning materials more visually appealing and understandable to students.

Figure 6.3 is an example of teachers' work which was made using the pre-prepared diagrams for the activities.

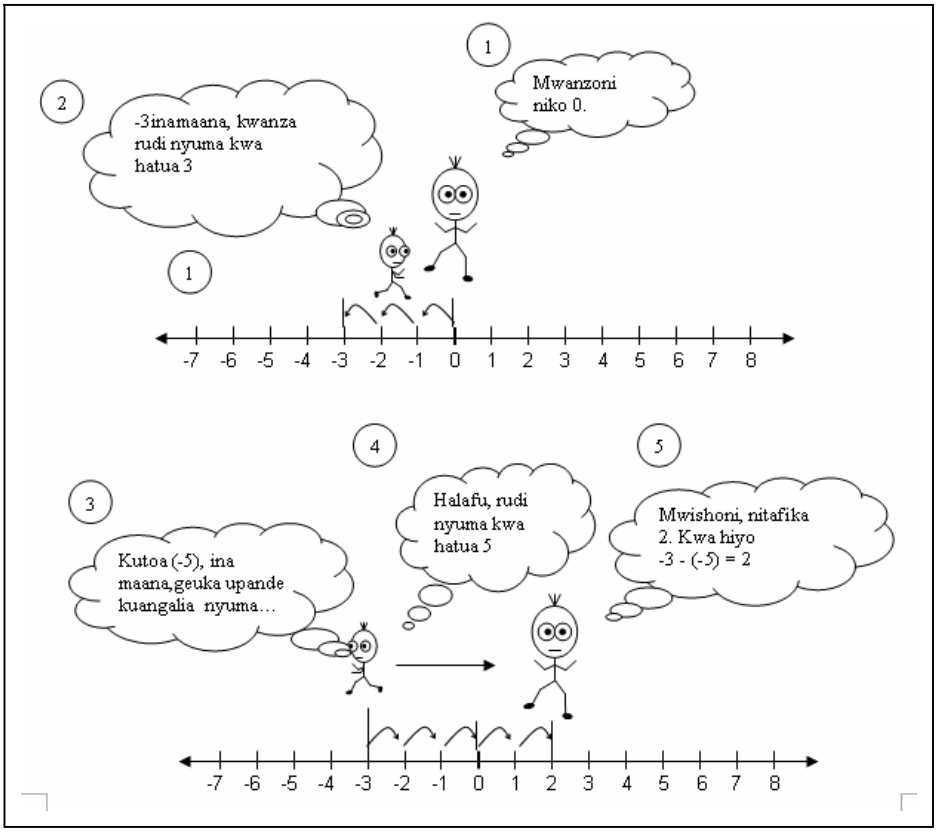


Figure 6. 3: Teacher's work of using pre-prepared diagrams for making materials

6.3 Evaluation and reflection on the training programme

6.3.1 Participants evaluations

At the end of the training, a semi-structured interview[10] was conducted with the participant teachers to know their impression and reflection about the training programme. The researcher firstly asked the teachers to fill in a questionnaire. After collecting the questionnaire a group interview was carried out based on the questionnaire.

All the participants were evaluated the activities of the training programme positively. Some of their comments were:

- *It was an educative programme since some new knowledge of using ICT had been added.*
- *It was good and new to me so I learnt a new idea.*
- *The activities were so impressive and interesting.*
- *It will be very useful to our day-to-day activities.*

[10] At Chang'ombe secondary school, due to the situational constraints, a Questionnaire, instead of semi-structured interview, was administrated to the participant teachers. At Lugalo secondary school the interview was conducted as a group at a place. The Interview was audio recorded.

They said that they gained benefit from the training in the following aspects:

- ✓ Gained knowledge of computer such as file management
- ✓ Learnt how to make a table using the tool bar
- ✓ Acquired some skills in drawing figures and diagrams using *MS Word*
- ✓ Learnt how to use digital images, how to copy figures and images to make another document
- ✓ Learnt how to start the Internet and how to download images from the internet
- ✓ How to use digital camera

Regarding the use of ICT tools, the participant teachers explained their impression, saying that:

- *It is easy if it is well organized. But it needs more time in thinking for production of relevant materials.*
- *It is not very difficult to use ICT tools and now I know how to use it. What I need is just the revisions.*
- *The use of ICT tools is easy and fast compared to other ways of making teaching materials..*
- *The use of the tools is easy provided that they are practiced frequently.*

From the participants' evaluation, the ICT training seems to have been interesting and useful for them. Especially drawing diagrams and using digital images using the word processing software were new and interesting topics for most of the teachers, which could be one of the reasons why the participants were very positive about the training. Use of the Internet was also an interesting topic for the participants.

The ICT training was conducted only for 5 working days. The participant teachers were engaged in the activities only for about 10 to 15 hours in total. Considering the fact that the teachers mastered computer skills to such an extent that they could make a rather complicated diagram such as the Figure 11, a short ICT training course like this one can contribute to enhance teachers' practice of using ICT tools.

6.3.2 Reflections - teachers' perception and practical challenges

The ICT training was basically designed to introduce basic ICT skills which were useful to make supplemental teaching/learning materials such as the mathematics handout made in the study. Although the participant teachers did not have enough time to make the material by themselves, because they learnt, in the training, basic techniques such as drawing diagrams with *MS word* and use of digital images, they admitted that it would not be very difficult for them to make such teaching/learning materials using computers available in the schools. However, when it comes to making a new teaching/learning material, teachers' idea for designing materials and didactical subject knowledge seem to become critical points. As was pointed out in the teacher questionnaire, lack of "creativity" amongst teachers is to be one of the constraints in practice.

In order to promote teachers' practice of using ICT tools for making supplemental teaching/learning materials, it is therefore of great importance to consider how to enhance teachers' pedagogical knowledge including methodology of designing effective materials, in parallel with promoting teachers basic knowledge and skills in ICT.

Chapter 7
Discussion

This last chapter summarizes the study and discusses its findings. Firstly section 7.1 briefly reflects on the study. Section 7.2 describes the overall findings in the study, which is followed by a discussion on the research approach in section 7.3. The chapter is closed by giving the conclusions and some recommendations drawn in the study in section 7.4.

7.1 Reflection on the study

This study was aimed to explore practical use of ICT by teachers for making supplemental teaching/learning materials as a way of supporting student learning in science and mathematics in secondary schools in Tanzania. The original motive of the study was derived from an observation made by the researcher that many O-level secondary school students made mistakes in basic arithmetic operations in Tanzania. At the start of the study, two assumptions were made: (i) If teachers can create and provide supplemental teaching/learning materials, it can be of great help to support student learning, thereby alleviate the problem. (ii) ICT can facilitate teachers' practice of making such supplemental materials in secondary schools. In order to explore the validity and practicality of these assumptions, the literature was reviewed to build a theoretical and empirical base for the study, and a field study was conducted at two secondary schools in Tanzania. The research question which guided the study was:

> ***How can ICT tools facilitate teachers' practice of making supplemental teaching/ learning materials in secondary schools in Tanzania?***

For elaboration of the main research question, the following sub-questions were formulated.

- *What materials may have relevance to support student learning in secondary schools in Tanzania?*
- *What ICT skills or experience do Tanzanian secondary school teachers have at present?*
- *How can teachers make use of ICT to develop teaching/learning materials?*
- *How do teachers perceive the use of ICT for the preparation of teaching/learning materials?*
- *What materials may practically be developed by teachers using ICT in secondary schools?*

In order to explore answers to these questions, the study adopted a development research approach. The field study was conducted to attempt three research components: (i) context analysis, (ii) material design and development and (iii) ICT training. Due to time limitation, the study mainly focused on the validity and practicality of the practice. Although evaluation of the material products and the programme of ICT training was a significant part of the development research, it was not systematically achieved. Only preliminary evaluations were made by observations of students' reactions and by interviews with the participant teachers.

In this chapter, the overall findings of the study are summarized in section 7.2, and then section 7.3 reflects the study focusing on the research approach. The tentative conclusions and recommendations in this study are described in section 7.4.

7.2 Overall findings and discussions

7.2.1 Context analysis - problems & roles of supplemental materials

The mathematics test which was administered to Form 1 and Form 4 students showed that a significant number of students, particularly in Form 1, did not understand the basic concept of arithmetic operations. In the test the students made similar mistakes to what was observed in other researches conducted in secondary schools in other regions (Sugiyama, 2003), which indicates that the problem of arithmetic operations is probably commonly observed in many (O-level) secondary schools in Tanzania. Because the arithmetic operations are basically taught in primary school, there is no appropriate teaching/learning material in secondary schools which can be used as a remedial measure to support the students who entered secondary schools with the poor basis of arithmetic operations. It was therefore expected that a supplemental teaching/learning material was to be developed to deal with the problem of arithmetic operations for the secondary school students.

The results of the biology test and the student questionnaire revealed that students, especially the lower grades such as Form 1, had difficulty in understanding scientific concepts or terminologies because of the language of instruction in secondary education that is English. Students perceived some topics in biology difficult to learn because of the language problems. It was therefore assumed that, especially for those students who have low English proficiency, supplemental teaching/learning materials would support student learning by giving language support in Kiswahili. To deal with the language problem, the materials are to be prepared depending on the linguistic level of students, and the degree of the language support is to be reduced according to the students' development of English proficiency.

7.2.2 Context analysis – teachers' use of ICT and practice of making materials

From the teacher questionnaire it was found that many teachers had very limited experience in using ICT even though they were working in the schools where computers were available. Although, especially in Chang'ombe secondary schools, the computers were used effectively for teaching computer science to students, it was observed that the computers were not much used by many teachers at the school. With regard to making supplemental teaching/learning materials, it was therefore not common practice for teachers to use the computers to make the supplemental materials. Although many teachers indicated that they often used teaching aids for their classes, they made the materials by handwriting.

It was informed from the teacher questionnaire, interview and informal conversation with teachers, as other school issues, the school administration plays an important role in promoting teachers' practice of using ICT in school. Regarding the teachers' practice of making supplemental teaching/learning materials, it was found that there was a gap between the teachers' perception and the headmasters' opinion about bureaucratic control over duplication of the materials.

It was observed, at the two schools, that teachers and schools often used photocopy machine either inside or outside the school to duplicate print materials such as test papers. It could be one of the reasons why teachers mentioned lack of financial support from the school as one of the constraints in making supplemental teaching/learning materials at the school.

7.2.3 Material design and development

From the literature review, three key notions; *motivation*, *visual representation* and *language support*, were adopted for the design features of supplemental teaching/learning materials, and a mathematics handout and a biology material were designed and developed in this study. The material contents and designs were informally evaluated by Tanzanian subject experts and a few teachers and revised based on their suggestions. Although the impact and effectiveness of the materials were not systematically evaluated in the study, teachers and students gave positive comments on the content and design features of the materials.

As for the language support, further consideration is needed concerning the effectiveness and relevance of the practice in Tanzanian secondary education in which English is the legislative language of instruction. It may need a further discussion with a number of people including teachers, students, parents and ministry officials.

In this study, materials were developed for dual purposes. Firstly the material development was necessary to provide examples of supplemental teaching/learning materials for the ICT training. As the motivational theory and empirical studies indicate, giving participants a clear image of task goals was considered as an important element for an effective in-service training. Secondly the materials were developed as a means to support student learning by giving them feedback about the test results. This practical target of the material development was expected to make the training tasks authentic and relevant to teachers working situations, which may be one of the reasons for the positive participation of the teachers in the ICT training.

7.2.4 ICT training

The ICT training was conducted to totally 10 science and mathematics teachers at the schools, and the training was highly appreciated by the participating teachers. Even though not all teachers could complete all the tasks prepared in the programme, teachers were eager to engage in the given tasks to learn new skills in using computers. Despite the limited time in the training teachers leant a various skills to draw diagrams with the conventional word processing software and made rather complicated drawings.

The ICT training was designed and conducted with the following four practical tips learnt from the literature: (i) practice-oriented training, (ii) flexible timeframe, (iii) involvement of the school administration, and (iv) consideration of teachers' motivation and the level of tasks. All in all, all the four conditions were meaningfully attained in the study. However, regarding the flexible time table, it was found that the balance of flexibility and rigid time control was, to some extent, necessary for real research practice (with much emphasis on the flexibility). When teachers come to the training randomly, it affects the programme management and causes a confusion for the researcher, which results in the decrease of the quality of training programme.

7.2.5 Practical use of computers in school

Although teachers' skill and experience of using computers were still limited at the two schools, it was observed that there would be some practical uses of computers by teachers apart from using computers for making supplemental teaching/learning materials intended in this research. A few examples are (i) Making the tests, (ii) Making instruction materials for practical experiments, (ii) Administrative works such as making a class list and keeping records of tests.

In the schools teachers were doing most of the above works manually. When a teacher conducted a practical experiment, she wrote on the blackboard all the instruction of the experiment. It was a time consuming work, and the instructions written on the board were somewhat difficult to read. If the teacher had prepared the instruction materials using a computer and made enough number of copies, it would not have taken a long time for the preparation of the experiment and the teacher could have concentrated in teaching activities.

7.3 Reflection of the research approach

7.3.1 Development research approach

This study adopted the concept of development research approach. One of the rationales to choose the approach was that there were many uncertainties for the research activities before starting the study. The flexible nature of the development research approach to pursue design principles and methodological ideal through the "*successive approximation*" (van den Akker, 1999) seemed to be appropriate for this exploratory study.

Development research is defined to have two purposes (i) to support prototypical material development providing empirical evidence for the effectiveness, and (ii) to generate methodological directions for the design and evaluation of the materials (van den Akker, 1999). However, in this study, due to the explorative nature of the study and time limitation, it was not possible to provide substantial "empirical evidence" for the effectiveness of the materials and its design approach.

Despite the significance of evaluation part of the research, the study had to focus more on the material development, and the design and operation of the ICT training programme. An evaluation of the materials developed in the study was informally carried out, when the materials were used in classroom to give feedback to students, by observing students' reactions. Since the supplemental teaching/learning materials developed in the study need to be revised and improved based on an evaluation(s) for the impact and effectiveness of the materials, the lack of systematic evaluation for the materials was a critical deficit in this study, and it is to be a prerequisite element for the next step.

7.3.2 The role of the researcher in ICT Training

In this study, the ICT training was aimed at attaining, at least, two purposes. Firstly, in line with the main research question (i.e. exploration of the roles of ICT tools to facilitate teachers' practice of making supplemental teaching/materials in the secondary schools), it was intended to observe teachers' skills of using ICT tools for making prototypical supplemental materials in the training. The second purpose was to contribute to increase teachers' confidence and skill in using ICT tools (i.e. ***mutual benefits***). As a result the researcher had to play multiple roles: observer, instructor, advisor and also designer (of the programme) at the same time in the training programme. This kind of multi-role functions of a researcher in research settings was noted as a problematic nature of development research (McKenney, 2001; Thijs, 1999; van den Akker, 1999). To understand and deal with this somewhat uncertain researcher's position, it is important to have a clear research plan to carry out the study.

The fact was that the researcher conducted the field research rather intuitively without having a firm methodological understanding on the research approach, holding uncertainty of the researchers' roles in his mind. The researcher tried to engage in different activities (observing,

teaching and designing) at the same time as scientifically as possible in the training programme as a part of research activities. After the research, it was reflected that, in order to carry out the research activities scientifically, it was of great importance to have sound understanding of methodological rationales of the research approach by which researcher's role(s) can be clearly defined at least for the researcher itself.

7.3.3 Reflections on the research activities

In order to have a clear understanding of the research approach, it is of great importance to have a well planed research framework before starting the study. In addition to the framework, it is also important to have research principles which can guide the researcher an appropriate direction when he or she encounters an uncertain situation in the research. Such research principles can also be useful to evaluate and reflect on the research activities to gain insights into the research approaches. In this study, partly because of the shallow understanding of the methodological approach, and partly because of the rush schedule for preparation of the research, the researcher started the field study without developing a well considered research principle(s).

McKenney (2001) who explored the potential of computer support system for curriculum material development in southern Africa, made the following five tenets as the research foundation for development research. (i) Local relevance, (ii) Collaboration, (iii) Authenticity, (iv) Mutual benefits and (v) Continuous (re)analysis. She used the tenets in formulating the research design and the development of instrumental tool. The five tenets are briefly explained as follows (McKenney, 2003):

- ***Local relevance****: any educational innovation must be carefully examined and, if necessary, (re)tailored for the context and culture in which it will be implemented.*
- ***Collaboration****: design and development activities (related to an innovation) must be conducted in collaboration with and not for those involved.*
- ***Authenticity****: efforts must be based on a working knowledge of the target setting and, where possible, research and development should be conducted in naturally-occurring test beds.*
- ***Mutual benefit****: a skillful attempt should be made to combine research activities with meaningful experiences for the participants.*
- ***Continuous (re)analysis****: careful and regular analysis of the risks and benefits of the innovation should be conducted in the light of the target setting, with design and development decisions being taken accordingly.*

Although this short-term exploratory study can never be comparable with her extensive multi-national research works, since there are some common aspects between the two studies (e.g. ICT use, science & mathematics, teacher training or teacher professional development, "locally relevant classroom material" development (McKenney, 2003), southern Africa especially Tanzania, and development research approach), the five tenets appear to be useful to reflect on the study to gain insights into the research activities. The following paragraphs describe reflections on the research based on the five tenets.

Mutual benefit

As one of the motives of development research is to "*strive after direct contributions to educational improvement process*" (van den Akker, 1999, p.2), this tenet was perceived by the researcher as one of the important aspects in the study. The study aimed at contributing to educational improvements at three levels; teachers, students and the school (administration).

As for teachers, the ICT training was aimed to contribute to increase teachers' ICT skills and knowledge, and the training was appreciated by the participating teachers. The mathematics test and biology test revealed problems amongst students, and it was aimed to raise teachers' awareness of necessity to support student learning. The tests were returned to students aiming to give them feedback from the test results to improve their understanding of the topics. With regard to contribution to the school, a tentative report during the research and a final report after the study were prepared by the researcher and submitted to the schools. The schools especially appreciated the reports about the academic problems found amongst their students.

Although the benefits they gained might not have been as much as the researcher expected, all in all, he had a feeling that the mutual benefit between the researcher and the schools was attained meaningfully to some extent, which, he believes, was one of the reasons why the research could have rather good cooperation from the schools including the participant teachers, the school administration and the students.

Collaboration

McKenney (2001, p.41) quotes Rogan (2000) who maintains "*[A]ny intervention needs to be done **with** and not **for** those involved, and should be appropriate to the needs of the schools and communities affected by the innovation*." This "*collaboration tenet*" (McKenney, 2001; 2003) was also regarded by the researcher as an important concern for the research. However, in the real research practice, because the researcher had to take more initiative in the activities due to the time limitation, the participating teachers played a rather passive role, and collaboration was not meaningfully attained in most cases. The only thing which was done collaboratively in the study was the development of supplemental teaching/learning materials, in which the researcher needed to work with teachers and subject experts to improve the design, content and the use of language in the materials.

Local relevance, Authenticity and Continuous (re)analysis

According to the formal and informal evaluation given by the participating teachers, the contents and approach of the research activities seems to be, fortunately, appropriate in the context. However these three principles, local relevance, authenticity and continuous analysis were somewhat difficult to effectively attain in the study.

One reason of the difficulty was the hasty condition of the research. The researcher did not have enough time to make a good preparation for the research before starting the activities. For example, he did not know in which schools the research would be carried out until he arrived in Tanzania. As for Lugalo secondary school, he had never been in the school. Therefore the research protocols including instruments had to be prepared without knowing the exact situation of the research places. These adverse conditions made it difficult to make a careful analysis of the local relevance and the situation of target settings. If another reason to be added, it should be pertinent to the explorative nature of study, which means that the aim of the study, per se, was to explore the context, culture, or risk and benefit of the intervention in the research setting within the short period.

7.4 Conclusions and recommendations

7.4.1 Conclusions

Although it is not easy to conclude something from a short exploratory research like this one, if tentative conclusions are required to draw, it may be summarized as below.

- Although most of the secondary school teachers are not much exposed to ICT at present, if facilities are available in school, and if teachers have a chance to learn basic skills of using computers, ICT tools such as computer and the Internet can effectively be used by secondary school teachers for making supplemental teaching/learning materials. Especially to make visually appealing materials with graphics such as diagrams and digital images, ICT has a great advantage for the practice. Such materials can be well developed with conventional word processing software using old type computers such as the ones used in this study. Teachers perceived the use of ICT not so difficult and showed a much interest in using ICT at the schools, particularly drawing diagrams with word professing software and using digital images to make printed materials are interesting and practical ICT skills for teachers. Making supplemental teaching/learning materials using ICT tools seems not to be too difficult for teachers, if adequate training and support are offered to them.

- However, when it comes to the real school setting, other situational conditions may become an obstacle in practice. One problem is limited availability and accessibility to the ICT tools in schools when teachers want to use the tools. Another constraint is the condition of material duplication, including supply of the stationary and availability of duplicating devises such as photocopy machine. In addition, administrative control for the use of equipments is perceived by teachers as a kind of obstacle for the practice. In order to enhance teachers' use of ICT for making supplemental teaching/learning materials in secondary schools, these problems need to be managed physically, financially and administratively.

- In addition to the financial and procedural constraints, teachers' problems such as lack of motivation, creativity and pedagogical knowledge may become other critical hurdles in the effort to enhance teaches' use of ICT tools for making supplemental teaching/learning materials. The ICT training is necessary in both pre-service and in-service teacher training in order to promote teachers' practical use of ICT in secondary schools. ICT training should offer not only the basic ICT skills (i.e. how to use the tools), but also the pedagogical and methodological approaches to make use of ICT so that teachers can find a way to use available ICT tools in the school to support student learning. Introducing drawing diagrams and use of digital images to create supplemental teaching/learning materials may be a few of the examples of useful and important topics in such ICT trainings for secondary school teachers.

7.4.2 Recommendations to promote ICT implementation in secondary schools

Some Teachers' Training Colleges have already started offering a computer course as a part of the curriculum. As a result, there are now young teachers who are equipped with basic skills of computers in secondary schools. So far major emphasis of the computer education in secondary education seems to have been placed on teaching the basic skills and knowledge to mainly students. However, in order to promote the use of ICT in schools to take advantage of the

available technology, it is also important to enhance teachers' practice of using ICT in schools.

- In order to promote teachers' use of ICT, teachers need training for the use of ICT tools. The in-service training for ICT should offer teachers practical skills which can be used in real school situation. In such an in-service ICT training, teachers should be well informed the purposes and the goals of the training programme. As was observed in the study, drawing diagrams and using digital images with the word processing software could be one of the practical skills which teachers find much interest and can be used for their practical works including making supplemental teaching/learning materials.

- As far as the basic use of computers is concerned, such as use of word processing programme for drawing diagrams and using digital images (except for high quality digital photos), old type computers like the ones which were used in this study can do the tasks. The point is that teachers should be encouraged to make good use of the available ICT tools in school, and the school should support teachers' practice by providing teachers with conducive environment for practical use of the ICT tools as much as possible. One of the key conditions to promote teachers' use of ICT for making supplemental teaching/learning materials is a reliable printing condition in the school. It is also desirable to make computers available in a place such as a department office where teachers can access to the computer when they need. For all these administrative issues, to enhance the mutual understanding and trust between teachers and the school administration is an important key element in an effort to promote teachers' use of ICT in school as is the case of the most school activities.

- Introduction of ICT in school is a very different task from teaching conventional subjects in classroom. In some cases an ordinal subject teacher may need to work as the computer teacher in school. However, in such a case, he or she should be exempted from teaching his/her subject in classroom so that the teacher can concentrate on teaching computer and also work effectively to maintain the condition of the facilities. For example, in Chang'ombe secondary school, it was observed that the school was making good use of available old computers and the computer room. The school was offering the subject of computer science to students, and it was found that students had already mastered various computer skills such as drawing diagrams with word processing programme and making graphs with spreadsheets. The two computer teachers had played a significant roll in the computer literacy training as well as in the maintenance of the computer room in the school. In order to promote ICT education in the secondary schools, especially where there are several computers in the computer room, it is desirable for the school to have a computer instructor who is specialized for being in charge of computer education.

7.4.3 Recommendations for further research

Finally, in an effort to promote teachers' use of ICT for making supplemental teaching/learning materials as a way to support student learning in secondary schools in Tanzania, further researches are necessary to deepen theoretical and empirical knowledge for the intended practice. The topics on which a further research seems to be necessary may include the followings.

1. Study on the material design and exploration of effective use of materials

- Study on the topics on which materials may be used to support student learning (i.e.

Analysis on students' problems in science and mathematics).

- Theoretical and empirical study on the characteristics of effective materials design in terms of motivation, visual representations and language support, and also on the material design layout.
- Study on the effective use of language support to facilitate student learning in secondary schools.
- Study on the impact and effectiveness of materials on student learning.

2. Study on the good practices of ICT use in schools in developing countries

- Study on a good use of ICT by teachers in secondary schools (i.e. potentials of computers and other ICT tools)
- Study on an effective and practical administrative control for the ICT use.
- Cost performance of ICT use in secondary schools.

3. ICT training and support system for ICT use

- Study on the design of ICT training programme for secondary school teachers.
- Exploration of an effective support system to promote teachers' use of ICT for making materials.

References

Arthur, J. (2001), Perspectives on Educational Language policy and its implementation in African Classrooms: a comparative study of Botswana and Tanzania, *Compare*, *31*(3), 347-362

Benson,C. (2002). Real and potential benefits of bilingual programmes in developing countries. *International Journal of Bilingual Education and Bilingualism, 5*(6), 303−317.

Benson, C. (2004). Bilingual schooling in Mozambique and Bolivia: From experimentation to Implementation. *Language Policy*, *3*, 47-66.

Brock-Utne, B. (2003). *But English is the language of science and technology - the language of instruction in Africa - with a special look at Tanzania*. Paper presented at the conference of Network for research and evaluation on education and development (NETREED), December 8-10, Gausdal, Norway. Retrieved on August 10, 2005 from the World Wide Web: http://www.netreed.uio.no/articles/Papers_final/brock_utne.pdf

Brock-Utne, B & Holmarsdottir. (2004). Language policies and practice in Tanzania and South Africa: problems and challenges, *International Journal of Educational Development*, *24*, 67-83

Carlson, R., Chandler, P., & Sweller, J. (2003). Learning and understanding science instructional material. *Journal of Educational Psychology*, *95*(3), 629-640.

Carney, R.N., & Levin, J.R. (2002). Pictorial Illustrations *Still* Improve Students' Learning From Text. *Educational Psychology Review, 14*(1), 5-26.

Chonjo, P.N., Osaki. K.M., Possi, & Mrutu, M. (1995). *Situational analysis of science teaching in government secondary schools in mainland Tanzania*. A repot submitted to MoEC and GTZ. Dar es Salaam: MoEC/GTZ.

Collins, A., Brown, J.S., & Newman, S.E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L.B. Resnick (Ed.), Knowing, learning and instruction: Essay in horror of Robert Glaser (pp.453-494). Hillsdale: Erlbaum.

Coppard, D. (2004). INSET of Secondary School Science and Mathematics Teachers. In K. O-saki, K. Hosea & W. Ottevanger (Eds.), *Reforming science and mathematics education in Sub-Sahara Africa,* (pp. 171-178). Dar es Salaam: Teams Project

Cox, M., Webb, M., Abbott, C., Blakeley, B., Beauchamp, T. & Rhodes, V. (2003). *ICT and Pedagogy: A review of the research literature*. ICT in Schools Research and Evaluation Series, No.18. London: Becta.

Cummins, J. (1999). Alternative paradigms in bilingual education research: Does theory have a place? *Educational Researcher, 28*(7), 26-32.

de Feiter, L., Vonk, H. & van den Akker, J. (1995). *Towards more effective science teacher development in Southern Africa*. Amsterdam: VU University Press

Dlodlo, T.S. (1999). Science Nomenclature in Africa: Physics in Nguni. *Journal of research in science teaching, 36*(3), 321–331.

Driscoll, M.P. (2002). Psychological foundation of instructional design. In R. A. Reiser & J.V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (pp. 58-69). Upper Saddle River, NJ: Merrill Prentice Hall.

Fullan, M. (2001). *The new meaning of educational change* (3rd ed.). New York: Teachers College Press

Gagnés, R. M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart & Winston.

Gellevij, M., & van der Meij, H. (2004). Empirical proof for presenting screen captures in software documentation. *Technical communication, 51*(2), 224-238.

Gellevij, M., van der Meij, H., de Jong, T. & Pieters, J. (2002). Multimodal versus unimodal instruction in a complex learning context. *The Journal of Experimental Education*, *70*(3), 215–239.

Githua, B.N., & Mwangi, J.G. (2003). Students' mathematics self-concept and motivation to learn mathematics: relationship and gender differences among Kenya's secondary-school students in Nairobi and Rift Valley provinces. *International Journal of Educational Development,23*, 487-499

Gray, B.V., (1999). Science education in the developing world. Issues and Considerations *Journal of Research in Science Teaching,36* (3), 261-268

Guskey, T.R. (2002). Professional development and teacher change. *Teachers and Teaching: theory and practice, 8*(3/4), 381-391.

Guttman, C. (2003). *Education in and for the Information Society*. Paris, UNESCO. Retrieved on September 10, 2005 from the World Wide Web: http://portal.unesco.org/ci/en/ev.php-URL_ID=12846&URL_DO=DO_TOPIC&URL_SECTION=201.html

Howie, S. (2002). *English language proficiency and contextual factors influencing mathematics achievement of secondary school pupils in South Africa.* Doctoral dissertation. Enschede: University of Twente.

Keller, J.M. (1983). Motivational design for instruction: In C.M.Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Keller, J.M., & Litchfield, B.C. (2002). Motivation and performance. In R. A. Reiser & J.V. Dempsey (Eds.), Trends and issues in instructional design and technology (pp. 84-98. Upper Saddle River, NJ: Merrill Prentice Hall.

Keller, J.M., & Suzuki, K. (2004). Learner motivation and E-learning design: a multinationally validated process. *Journal of Educational Media, 29*(3), 229-239.

Kitta, S. (1994). *Some problems encountered in the teaching and learning of mathematics in the secondary schools in Tanzania: A case study of secondary schools in Arusha region*. MSc thesis. Dar es Salaam: University of Dar es Salaam.

Kitta, S. (2004). *Enhancing mathematics teachers' pedagogical content knowledge and skills in Tanzania.* Doctoral dissertation. Enschede: University of Twente.

Kitta, S., Thijs, A. & van den Berg, E. (2002). Peer collaboration in schools: The support for mathematics teachers' professional development, In K. O-saki, W. Ottevanger, C. Uiso and J. van den Akker (Eds.), *Science education research and teacher development in Tanzania* (pp. 83-102). Amsterdam, Vrije Universiteit Printers.

Kozma, R., McGhee, R., Quellmalz, E., & Zalles, D. (2004). Closing the digital divide: evaluation of the World Links program. *International Journal of Educational Development, 24*, 361–381.

Matthews, M.R. (2002). Constructivism and Science Education: A Further Appraisal. *Journal of Science Education and Technology*, *11*(2),121-134.

Mayer, R.E., & Sims, V. (1994). For whom is a picture worth a thousand words? Expectations of a Dual-Coding Theory of Multimedia learning. *Journal of Educational Psychology, 86*(3), 389-401.

Mazigo, E.M. (2003). *Factors influencing poor performance in Basic Mathematics and remedies*. Paper presented at the meeting between Japan Overseas Cooperation Volunteers and Ministry of Education and Culture, 20th June, Dar es Salaam.

Mayer, R.E., & Massa, L.J. (2003). Three facets of visual and verbal learners: cognitive ability, cognitive style, and learning preference. *Journal of Educational Psychology*, *95*(4), 833–846.

McFarlane, A. & Sakellariou, S. (2002). The role of ICT in science education. *Cambridge Journal of Education, 32* (2), pp. 219-232.

McKenney, S. (2001). *Computer-based support for science education materials development in Africa*. Doctoral dissertation. Enschede: University of Twente.

McKenney, S. (2003). *Using technology to support both teacher professional development and curriculum development in southern Africa: A case study*. Washington DC: World Bank.

MoEC (Ministry of Education and Culture) (1995). *Education and training policy*. Dar es Salaam: MoEC.

MoEC (Ministry of Education and Culture) (1997). *Basic mathematics syllabus*. Dar es Salaam: MoEC.

MoEC (Ministry of Education and Culture) (2002). *Basic Statistics in Education: National Data, June 2002*. Dar es Salaam. MoEC.

MoEC (Ministry of Education and Culture) (2005). *Provisional biology syllabus for secondary schools Form 1. January 2005*. Dar es Salaam. MoEC.

MoCT (Ministry of Communication & Transport) (2003). *National information and communications technologies policy: March 2003*. Retrieved on August 14, 2005 from the World Wide Web: http://www.moct.go.tz/THE_UNITED_REPUBLIC_OF_TANZANIA.pdf

Motswiri, M.J. (2004). *Supporting chemistry teachers in implementing formative assessment of investigative practical work in Botswana*. Doctoral dissertation. Enschede: University of Twente.

Mwaluko, D. (1997). *Girls and physics in Tanzania: Analysis on girls students' perceptions of physics in advanced secondary education*. Unpublished Master thesis. Enschede: University of Twente.

Nieveen, N. (1999). Prototyping to research product quality. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & Tj. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 125-135). Dordrecht, Kluwer Academic Publishers.

Ogunniyi, M. (1996). Science, technology and mathematics: The problem of developing critical human capital in Africa. *International Journal of Science Education*,*18*(3), 267-284.

O-saki, K. (2004a). Reflections on the state of science education in Tanzania. In K. O-saki, K. Hosea & W. Ottevanger (Eds.), *Reforming science and mathematics education in Sub-Sahara Africa*, (pp. 11-26). Dar es Salaam: Teams Project.

O-saki, K. (2004b). Tanzania: *Reflections on the secondary education analysis and secondary education development programme*. Paper presented at the World Bank Conference on Secondary Education in Africa, 6-9, June, Dakar.

Osborne, J. & Hennessy, S. (2003). *Literature Review in Science Education and the Role of ICT: Promise, Problems and Future Directions*. NESTA futurelab series, Report 6. Bristol: NESTA Futurelab. Online available : http://www.nestafuturelab.org/research/reviews/se01.htm

Osin, L. (1998). *Computers in education in developing countries: Why and How?* Education and Technology Series, (3) 1, 1-14, also available from the World Wide Web: http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_99031910575710)

O'Sullivan, M. (2004). The reconceptualisation of learner-centered approaches: a Namibian case study. *International Journal of Educational Development*, *24*, 585-602.

Ottevanger, W. (2001). *Teacher support materials as a catalyst for science curriculum implementation in Namibia*. Doctoral dissertation. Enschede: University of Twente.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist*, *38*(1), 1-4.

Paivio, A. (1990). *Mental representations: a dual coding approach*. New York: Oxford University Press.

Rogan, J., & Aldous, C. (2005). Relationships between the Constructs of a Theory of Curriculum Implementation. *Journal of research in science teaching*, *42*(3), 313–336.

Roy-Campbell, Z.M. (2001). Globalisation, language and education: a comparative study of the United States and Tanzania, *International Review of Education*, *47* (3-4), 267-282.

Roy-Campbell, Z.M. & Qorro, M.A.S. (1997). Language Crisis in Tanzania. Dar es Salaam: Mkuki Na Nyota Publishers

Rubagumya, C.M. (1991). Language promotion for educational purposes: The example of Tanzania. *International Review of Education*, *37* (1), 67-85.

Rubagumya, C.M. (1994). Language values and bilingual classroom discourse in Tanzanian secondary schools. *Language, Culture and Curriculum, 7* (1), 41- 53.

Scheiter, K., Gerjets, P. & Catrambone, R. (in press). Making the abstract concrete: Visualizing mathematical solution procedures. *Computers in Human Behavior.*

Sekwao, N.V. (1986). *Factors which contribute to poor performance in A-level science subjects with special references to Biology in Tanzania. The case of Coast, Dar es Salaam and Morogoro regions*, MSc thesis. Dar es Salaam, University of Dar es Salaam.

Setati, M. (2005) Mathematics education and language: policy, research and practice in multilingual South Africa. In R. Vithal, J. Adler & C. Keitel (Eds.), *Researching Mathematics Education in South Africa, Perspectives, practices and possibilities*, (pp. 73-109). HSRC press. Retrieved on July 27, 2005 from the World Wide Web: http://www.hsrcpress.ac.za/index.asp?id=2034

Shumba, O. (1999). Relationship between secondary science teachers' orientation to traditional culture and beliefs concerning science instructional ideology. *Journal of Research in Science Teaching,36* (3), 333-355.

Smith, P.L. & Ragan, T.J (1999). *Instructional Design* (2nd ed). New York [etc.]: John Wiley & Sons, Inc.

Stronkhorst, R.J. (2001). *Improving science education in Swaziland: the role of inservice education*. Doctoral dissertation. Enschede: University of Twente.

Sugiyama, M. (2003). *Mathematics Case Study in Secondary Schools*. Paper presented at the MoEC Annual General Meeting 2003, December 8-12, Arusha, Tanzania.

Tabulawa, R. (1997). Pedagogical classroom practice and the social context: The case study on Botswana. *International Journal of Educational Development*, *17*(2), 189-204.

Thijs, A. (1999). *Supporting science curriculum reform in Botswana: The potential of peer coaching*. Doctoral dissertation. Enschede: University of Twente.

Tilya, F. (2003). *Teacher support for the use of MBL in activity-based physics teaching in Tanzania*. Doctoral dissertation. Enschede: University of Twente.

Tilya, F. & Voogt, J. (2002). Teacher preparation and support in the use of microcomputer-based laboratories (MBL) for physics teachers in Tanzania. In K. O-saki, W. Ottevanger, C. Uiso & J. van den Akker, (Eds). *Science education research and teacher development in Tanzania* (pp. 103-120). Amsterdam: Vrije Universiteit Printers.

TIMSS (2004). *IEA's Trends in International Mathematics and Science Study (TIMSS) 2003*, Retrieved on July 27, 2005 from the World Wide Web: http://timss.bc.edu/timss2003i/intl_reports.html

Todd, A., & Mason, M. (2005). Enhancing learning in South African schools: strategies beyond outcomes-based education. *International Journal of Educational Development*, *25*(3), 231-235.

UNESCO (2002). *Information and Communication Technologies in teacher education: A planning guide.* Paris, UNESCO.

Unwin, T. (2005). Towards a framework for the use of ICT in teacher training in Africa. *Open Learning*: *Journal of Open and Distance Education, 20*(2), 113-129.

Urassa, F.M. & O-saki, K.M. (2002). Pre-entry programme for science female students at the University of Dar es Salaam: status and progress, 199602001, In K. O-saki, W. Ottevanger, C. Uiso and J. van den Akker, (Eds). *Science education research and teacher development in Tanzania* (pp. 69-81). Amsterdam: Vrije Universiteit Printers.

URT-NW (United Republic of Tanzania National Website) (2005). *Economy, Economic performance*. Retrieved on July 14, 2005 from the World Wide Web: http://www.tanzania.go.tz/economyf.html

van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & Tj. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 1-13). Dordrecht: Kluwer Academic Publishers.

van den Akker, J. (2003). Curriculum perspectives: An Introduction. In J. van den Akker, W. Kuiper & U. Hameyer (Eds.), *Curriculum Landscapes and Trends* (pp. 1-10). Dordrecht, Kluwer Academic Publishers.

van den Berg, E., Blijleven, P. & Jansen, L. (2003). Digital learning Materials: Classification and Implication for the Curriculum. In J. van den Akker, W. Kuiper & U. Hameyer (Eds.), *Curriculum Landscapes and Trends* (pp.237-254). Dordrecht: Kluwer Academic Publishers.

van der Meij, H., & Carroll, J.M. (1995). Principles and heuristics for designing minimalist instruction. *Technical communication, Second quarter,* 243-261.

Vikiri, I. (2002). What is the value of graphical display in learning? *Educational Psychology Review, 14*(3), 261-312.

Voogt, J. (2002). Developments of ICT in Science education. In K. O-saki, W. Ottevanger, C. Uiso & J. van den Akker (Eds.), *Science education research and teacher development in Tanzania* (pp. 39-50). Amsterdam: Vrije Universiteit Printers.

Voogt, J. (2003). Consequences of ICT for aims, contents, processes, and environments of learning. In J. van den Akker, W. Kuiper & U. Hameyer, (Eds.) *Curriculum Landscapes and Trends* (pp. 217-236). Dordrecht: Kluwer Academic Publishers

Vygotsky, L.S. (1978). *Mind and society: Development of higher psychological processes.* Cambridge, MA: Harvard University Press.

World Bank Group (2003). *ICT at a glance Tanzania*. Retrieved on July 14, 2005 from the World Wide Web: http://www.worldbank.org/cgi-bin/sendoff.cgi?page=%2Fdata%2Fcountrydata%2Fict%2Ftza_ict.pdf

World Bank Group (2004a). *Tanzania at a glance*. Retrieved on July 14, 2005 from the World Wide Web: http://www.worldbank.org/cgi-bin/sendoff.cgi?page=%2Fdata%2Fcountrydata%2Faag%2Ftza_aag.pdf

World Bank Group (2004b). *Tanzania - Secondary Education Development Program Project*, l(1). Retrieved on January 8, 2005 from the World Wide Web: http://web.worldbank.org/external/projects/main?pagePK=104231&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P083080

World Bank Group (2005a). *Tanzania Data File*. Retrieved on July 14, 2005 from the World Wide Web: http://www.worldbank.org/data/countrydata/countrydata.html

World Bank Group (2005b). *Tanzania Country Brief*. Retrieved on July 14, 2005 from the World Wide Web: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/TANZANIAEXTN/0,,menuPK:287345~pagePK:141132~piPK:141107~theSitePK:258799,00.html

Yin, R.K. (2002). *Case study research: design and methods*. 3rd edition. Thousands Oaks CA: Sage Publications.

Zembylas, M., & Vrasidas, C. (2005). Globalization, information and communication technologies, and the prospect of a 'global village': promises of inclusion or electronic colonization? *Journal of curriculum studies*, *37*(1), 65–83.

Appendices

Appendix A: Mathematics Test Questions

MATHEMATICS EXERCISES

Jina _____ Kidato _____ Jinsia (Weka ✔) : ☐ boy, ☐ girl

No	Mazoezi	Andika hesabu yako	Jibu	No
1	$5 + 2 \times 4 =$			1
2	$-6-3=$			2
3	$4 \times (-5) =$			3
4	$-2+5=$			4
5	$-5-(-3) =$			5
6	$8-(+4) =$			6
7	$6-(-3) =$			7
8	$-9-^{+}4 =$			8
9	$0-(-4) =$			9
10	$-5+(-2) =$			10
11	$(-16) \div (-4) =$			11
12	$-(8-3) =$			12
13	$-2-8=$			13
14	$8-4 \times 5 =$			14
15	$-7-^{-}5 =$			15
16	$-6+3=$			16
17	$-8 \div (-2) =$			17
18	$0-6=$			18
19	$(4 \times 3)-(2+5) =$			19
20	$4-^{-}7 =$			20
21	$(-3) \times (-6)$			21
22	$4 \times (2-5) =$			22
23	$-3-5=$			23
24	$7+(-2) =$			24
25	$-(4-7) =$			25
26	$2-6=$			26
27	$2 \times 4-(8 \div 2) =$			27
28	$-(5 \times 2) =$			28
29	$-2+4 \times 3=$			29
30	$-4+^{-}2 =$			30

Ahsante sana kujaribu

Appendix B: Results of Mathematic Test (Form 1 & Form 4)

*Table B1: Average Scores of **Form 1 students** (The Full Marks is 30)*

School		No of Students	Average Score	Total No Students	Average Score
Chang'ombe	Boy	*65*	*22.7*	*122*	*21.8*
	Girl	*57*	*20.7*		
Lugalo	Boy	*81*	*22.0*	*166*	*20.8*
	Girl	*85*	*19.6*		
Total				288	21.2

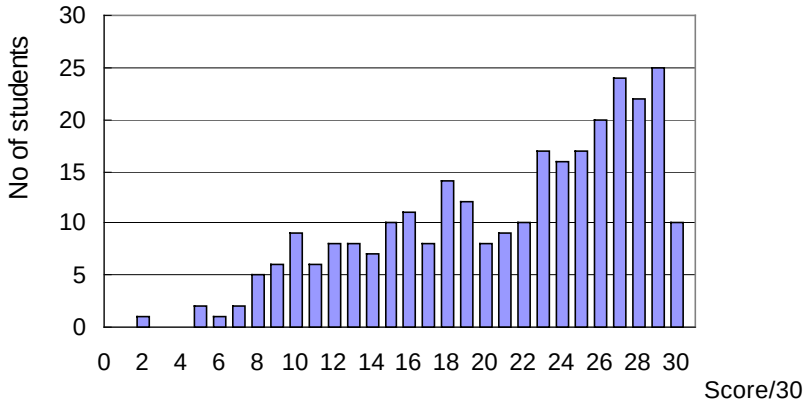


*Figure B1: Score distribution of the mathematics test (**Form 1**)*

*Table B2: Average Scores of **Form 4 students** (The Full Marks is 30)*

School		No of Students	Average Score	Total No Students	Average Score
Chang'ombe	Boy	*31*	*26.7*	*58*	*25.1*
	Girl	*27*	*23.3*		
Lugalo	Boy	*30*	*26.8*	*61*	*26.5*
	Girl	*31*	*26.2*		
Total				119	25.8

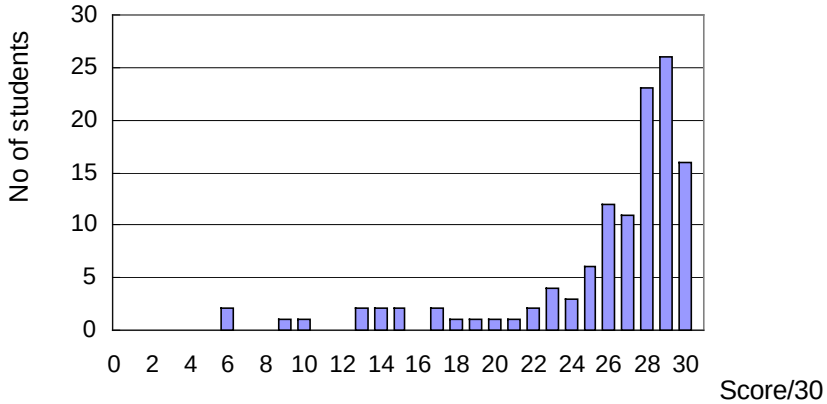


*Figure B2: Score distribution of the mathematics test (**Form 4**)*

Appendix C: Analysis on the results of Mathematic Test

The questions with higher rates of mistakes (more than 30% in Form 1, more than 20% in Form 4) are shaded.

No	Question	Correct answer	% of the students who gave a wrong answer to the question	
			Form 1	Form 4
Type 1: Addition / subtraction (Miscellaneous)				
7	6 – (- 3) =	9	29.9%	11.8%
24	7 + (- 2) =	5	19.8%	7.6%
6	8 – (+ 4) =	4	19.8%	7.6%
26	2 – 6 =	- 4	16.7%	3.4%
Type 2: Addition for a negative number				
10	- 5 + (- 2) =	- 7	25.7%	10.9%
16	- 6 + 3 =	- 3	22.9%	9.2%
4	- 2 + 5 =	3	21.2%	7.6%
Type 3: Subtraction for a negative number				
23	- 3 – 5 =	- 8	44.8%	12.6%
13	- 2 – 8 =	- 10	43.8%	12.6%
2	- 6 – 3 =	- 9	40.6%	8.4%
Type 4: Subtraction for zero				
18	0 – 6 =	- 6	41.7%	13.4%
9	0 – (- 4) =	4	36.8%	9.2%
Type 5: Subtractions with brackets				
25	- (4 – 7) =	3	47.6%	21.8%
12	- (8 – 3) =	- 5	37.5%	21.8%
5	(- 5) – (- 3) =	- 2	26.7%	13.4%
Type 6: Subtraction & use of small positive/negative signs				
8	- 9 – $^{+}$4 =	- 13	49.7%	27.7%
20	4 – $^{-}$ 7 =	11	34.0%	13.4%
15	- 7 – $^{-}$ 5 =	- 2	30.9%	7.6%
30	- 4 + $^{-}$ 2 =	- 6	24.0%	4.2%
Type 7: Multiplication / Division with negative number				
17	- 8 ÷ (- 2) =	4	18.8%	10.9%
21	(- 3) × (- 6)	18	13.5%	7.6%
11	(- 16) ÷ (- 4) =	4	14.2%	11.8%
3	4 × (- 5) =	- 20	8.7%	5.9%
Type 8: Order of calculations (BODMAS)				
14	8 – 4 × 5 =	- 12	48.6%	22.7%
29	- 2 + 4 × 3 =	10	37.8%	17.6%
28	- (5 × 2) =	- 10	37.8%	42.0%
1	5 + 2 × 4 =	13	33.0%	31.9%
22	4 × (2 – 5) =	- 12	26.4%	13.4%
19	(4 × 3) – (2 + 5) =	5	19.4%	23.5%
27	2 × 4 – (8 ÷ 2) =	4	9.7%	6.7%

Appendix D: Biology Test Questions

Mazoezi ya Biology

Kidato _____ Jina _____ Jinsia (Weka ✔) : ☐ boy, ☐ girl

Madhumuni ya mazoezi hili ni kuelewa matatizo ya wanafunzi wa shule za sekondari kuhusu lugha za Kingereza katika masomo ya biologia. Tunatangulize shukurani zetu za dhati za wewe kukubali kushiriki katika zoezi hili. Ushiriki wako utusaidia kuboresha ufundishaji na ujifunzaji wa somo la sayansi. Ahsante sana.

Chagua moja katiya (a), (b), (c), (d) ambayo inaeleza vizuri zaidi maana ya kila neno la kisayansi.

1. **Observation** → jibu _____
   a) Jinsi au utaratibu wa kufanya majaribio katika maabara
   b) Matayarisho kwa majaribio
   c) Jinsi ya kuangalia kitu kwa makusudi ya kugundua kitu fulani
   d) Kanuni ya kufanya utafiti wa kisayansi

2. **Hypothesis** → jibu _____
   a) Maelezo yanayo tolewa na wataalamu
   b) Maelezo kwa nadharia tete.
   c) Matokeo ya majaribio ya maabara
   d) Maelezo yenye makosa fulani

3. **Conclusion** → jibu _____
   a) Maelezo ya kujaribu kueleza mawazo ya kisayansi.
   b) Matokeo ya majaribio ya maabara.
   c) Nadharia kukubaliwa na wataalamu.
   d) Maelezo yanayo tolewa kutokanana matokeo ya majaribio au utafiti.

4. **Reproduction** → jibu _____
   a) Jinsi viumbe hai wanavyokua.
   b) Jinsi viumbe hai wanavyopata nishati au nguvu.
   c) Jinsi viumbe hai wanavyozaliana.
   d) Jinsi viumbe hai wanavyotengeneza mali.

5. **Infection** → jibu _____
   a) Jinsi viumbe hai wanavyoongeza ukubwa wa jamii
   b) Maambukizo ya ugonjwa au vijidudu vinasababishavyo ugonjwa
   c) Jinsi viumbe hai uwa viumbe wengine.
   d) kupiga sindano mwilini

Asante sana kukubali kufanya mazaezi na muda wako.

Appendix E: Summary of Student Questionnaire

Participants: 117 Form 4 students

	Girl	Boy	Total
Total	57	60	***117***

*1. In science subjects, which subject do you **like** the most?*

	Physics		Chemistry		Biology	
	Girl	Boy	Girl	Boy	Girl	Boy
Sub Total	3	14	12	14	40	32
Total	17		26		72	
%	14.8 %		22.6 %		**62.6 %**	

- The total number of students does not amount to 117 because there were students who did not answer the question.

2. In science subjects, which subject do you dislike the most?

	Physics		Chemistry		Biology	
	Girl	Boy	Girl	Boy	Girl	Boy
Sub Total	43	33	7	13	3	12
Total	76		20		15	
%	**68.5 %**		18.0 %		13.5 %	

- The total number of students does not amount to 117 because there were students who did not answer the question.

3. If you compare with other science subjects, what do you think about Biology?

	Very difficult		Somehow difficult		Easy		Very easy	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
Sub Total	5	2	36	43	9	12	4	4
Total	7		79		21		8	
%	6.1 %		**68.7 %**		18.3 %		7.0 %	

- The total number of students does not amount to 117 because there were students who did not answer the question.

*5. In the topic of Biology taught in Form 1 and Form 2, which topic do you think the most difficult to understand? Please choose **TWO topics** from below.*

Topic in Biology (Form 1 & 2)	Form 4		Total	
	Girls	Boys		
Concept of Biology & Scientific methods	5	3	8	6.8%
Cell structure and Organization	7	1	8	6.8%
Classification,	19	32	51	43.6%
Health and prevention of diseases	14	21	35	29.9%
Nutrition in plants	8	10	18	15.4%
Human Nutrition	0	2	2	1.7%
Gasesous exchange	16	16	32	27.4%
Respiration	13	10	23	19.7%
Transport	9	6	15	12.8%
Movement	17	9	26	22.2%

- There were students who choose no or only one topic from the choices.

Appendix F: Teacher Questionnaire

Questionnaire for Teachers

Dear Sir/Madam,

I would like to ask you for your kind corporation to take a time to answer this questionnaire. The major purpose of this questionnaire is to collect information from secondary school teachers as to the situation of use of ICT and also as to the use of supplemental teaching/learning materials in school. I would like to assure you that the information you provide will be handled strictly confidential, and be used for the research purpose only.

General Information

1. Please indicate your **sex**. ☐ Male, ☐ Female
2. What is your **age**? ☐ 20s, ☐ 30s, ☐ 40s, ☐ 50s
3. What kind of educational **qualification** do you have?
   ☐ Master of Ed/Sc, ☐ Bachelor of Ed/Sc, ☐ Diploma, ☐ Other, namely _____
4. What is your **teaching experience**? _____ **years**.
5. What **subject(s)** are you teaching now?
   ☐ Mathematics, ☐ Physics, ☐ Chemistry, ☐ Biology,
   ☐ English, ☐ Swahili, ☐ Geography, ☐ History, ☐ Economy,
   ☐ Home economics, ☐ PE, ☐ General study, ☐ Other, namely _____
6. How many **teaching period** do you have in total? _____ **periods / week**
7. Do you have any special **role** in your school? (e.g. HoD, Class master, etc)
   _____

Questions as to use of Information Communication Technology

8. Do you have your own **computer at home**? ☐ Yes, ☐ No
9. How often do you have a **chance to use a computer**?
   ☐ Never used, ☐ Very rare, ☐ A few times a month, ☐ A few times a week, ☐ Almost every day
10. If you have an experience of using computer, what **software programme** do you mainly use?
    ☐ Word processor (e.g. MS Word), ☐ Spread sheet (e.g. MS Excel),
    ☐ Presentation (e.g. MS Power point), ☐ Drawing (e.g. MS Paint),
    ☐ Other, namely _____
11. How do you evaluate your own **computer skill**?
    ☐ Very good, ☐ Good, ☐ Moderate, ☐ Weak, ☐ Very poor
12. How often do you use **the Internet**?
    ☐ Never used, ☐ Very rare, ☐ A few times a month, ☐ A few times a week, ☐ Almost every day
13. How often do you use **e-mail**?
    ☐ Never used, ☐ Very rare, ☐ A few times a month, ☐ A few times a week, ☐ Almost every day

Please find other questions on the next page.

Questions as to Supplemental Teaching/Learning Materials

On the last page, you can find examples of materials which are meant by teaching/learning materials in this questionnaire. Please take a look at them first and answer the following questions.

14. **How often do you use** extra teaching / learning materials (e.g. teaching aids, printed materials, etc) in your lesson apart from the Text books?

☐ Never used, ☐ Very rare, ☐ Sometimes, ☐ Often, ☐ Almost every lesson

15. Have you ever made **by yourself** any handout (printed materials) to give students for lesson?

☐ Yes,

☐ No → go to question 18.

16. If you have made the materials before, **how did you make** the materials?

☐ By asking the secretary,

☐ By yourself → ☐ With hand writing, ☐ With a typewriter, ☐ With a computer

17. When you made the material, how did you make enough copies of the materials?

☐ With a duplicating machine in the school, ☐ With a copy machine in the school

☐ With a copy machine in the TTC, ☐ With a copy machine in a shop outside the school

☐ Other way, namely _____

18. Many teachers agree that a supplemental teaching/learning material can be helpful for student learning. However it seems in general that teachers do not make such materials in practice in school. What do you think the **reasons** for? What **constraints or problems** do you think teachers have to make such teaching/learning materials?

19. Do you think **you can find time** to make such teaching learning materials for students?

☐ Yes,

☐ No → Please briefly explain why.

20. There are students in secondary school who have difficulty in understanding basic concept of science or mathematics. For example some students don't understand the basic arithmetic operational rules and make mistakes such as $-9-6=-3$ or $0-5=0$. In order to help them understand the basic concept such as arithmetic operations, what do you think secondary school teachers can do?

Ahsante sana

Appendix G: Teachers' profiles

The figure G1 and G2 show the profile of the respondents. Out of 62 respondents, 32 were female and 30 were male. There was a wide range of respondents' age and teaching experiences. From the figures, it can be assumed that the sample population in this questionnaire was not extremely biased in terms of sex, age and their teaching experiences.

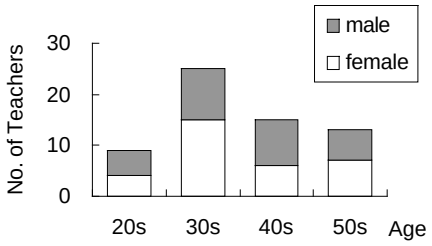


Figure F1: Age distribution

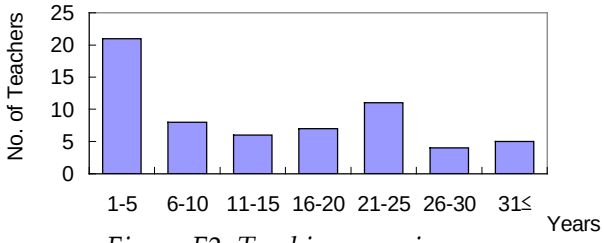


Figure F2: Teaching experience

Table G1 shows the number and qualification of teachers who responded to the questionnaire. Three teachers had a qualification of neither Graduate nor Diploma. One of them was teaching physical education. Another one held a special certificate for fine arts. The third one was a Form 6 leaver who was in charge of youth activities which was not official subject.

Table G1: Qualifications of teachers

	Qualification			Total
	Graduate	*Diploma*	*Others*	
Female	1	31	0	32
Male	6	21	3	30
Total	7	52	3	62

Figure G3 shows teaching loads of the teachers who responded to the questionnaire. From the figure it can be seen that majority of the teachers were not overloaded in terms of teaching periods. They had a less or an appropriate teaching load according to the Ministry's policy which states 24 periods per week as an appropriate teaching load for secondary school teachers (MoEC, 1995)[1]. The teachers who had less than 5 periods per week involve two head-teachers and a SESS regional technical officer. The Form 6 leaver mentioned above was also included in this category.

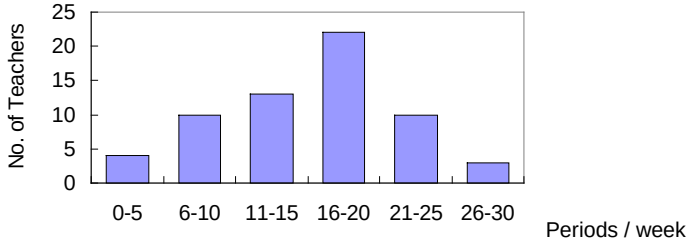


Figure G3: Distribution of teaching loads

[1] Ministry of Education and Culture (MOEC) (1995). *Education and training policy*. Dar es Salaam: MoEC.

Appendix H: Profile of Participant Teacher in ICT training

Questionnaire items	Teachers									
0. Name	A	B	C	D	E	F	G	H	I	J
1. Sex	Male	Female	Male	Female	Female	Female	Female	Male	Male	Male
2. Age	30s	20s	30s	30s	30s	30s	40s	20s	30s	40s
3. Qualification	Diploma	Diploma	Diploma	Diploma	Diploma	Diploma	Diploma	Diploma	Diploma	Diploma
4. Teaching experience (years)	9	3	2	9	5	5	20	1	10	24
5. Teaching subjects	Math	Math & Geo	Math & Phy	Bio	Bio & Phy	Bio & Phy	Chem	Math	Phy	Math
6. Teaching load (periods/week)	24	24	12	12	10	16	12	24	16	18
7. Special role in school	HoD									HoD
8. Do you have your own computer at home?	No	No	No	No	No	No	Yes	No	No	No
9. How often do you have a chance to use computer?	very rare	very rare	A few times a month	very rare	very rare	A few times a month	few times a week	few times a week	few times a month	few times a month
10. What software program do you usually use?	Word processor		Word processor Spread sheet	Word processor	Word processor	Word processor	Spread sheet	Word processor Spread sheet	Word processor	Word processor Spread sheet, game
11. How do you evaluate you own computer skill?	Weak	Weak	moderate	Weak	Weak	Moderate	moderate	moderate	moderate	moderate
12. How do you evaluate your typing skill?	Weak	Weak	Moderate	moderate	Weak	Moderate	moderate	moderate	Moderate	moderate
13. How/where did you learn the use of PC?	Private tuition	Never learnt	TTC	Private tuition	Private tuition	Private tuition	Private tuition	TTC	course	course
14. How often do you use CD-ROM (excluding the music CDs)?	Very rare	Never used	Never used	Never used	Never used	Never used	few times a week	Very rare	Very rare	Never used
15. How often do you use Digital camera?	Never used	Never used	Never used	Never used	Never used	Never used	Never used	Never used	Very rare	Never used
16. How often do you use Scanner?	Never used	Never used	Never used	Never used	Never used	Never used	Never used	Very rare	Very rare	Never used
17. Did/do you have your own e-mail address?	Never had	Never had	Yes, have	Never had	Never had	Never had	Yes, have	Never had	No, but I had one	Never had
18. How often do you use e-mail?	Never used	Never used	A few times a month	Never used	Never used	Never used	Very rare	Never used	Very rare	Never used
19. How often do you use the Internet?	Never used	Never used	A few times a month	Never used	Never used	Never used	few times a week	few times a week	Very rare	Never used
20. If you use the internet, what do you do with the Internet?			To check e-mail				To look at Interesting web sites,	To look at Interesting web sites,	To look at Interesting web sites,	
21. Have you ever used ICT tools such as computers for teaching lessons?	No	No	No	No	No	No	No	No	No	No
22. Can you make a table with MS-word?	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
23. Can you make a drawing with MS-word?	Yes	No	No	No	No	No	No	No	No	No
24. Can you make use of an image (clip art) with MS-word?	No	No	No	No	No	No	Yes	No	No	No

Appendix I: Teacher interview scheme

1. How did you see / evaluate the activities in the programme? **General impressions**.
2. What **benefit** do you think you had/gained in this program, if any?
3. What did you see in the use of ICT tools in general? How did you perceive the use of tools? Difficult or easy?
4. Which aspect / type of ICT tools do you think the most useful for teachers in making supplemental teaching/learning materials?
5. How do you think you can make use of ICT tools for making teaching/learning materials?
6. What problems do you think teachers may have to make teaching/learning materials using ICT tools in the school ***in practice***?
7. What do you think teachers or school should/can do to overcome the problems?

Appendix J: Supplemental teaching/learning material - Mathematics

Arithmetic Operation

1. Use of Number line for addition and subtraction

Many students make mistakes for the questions below.

He! Kahisi tu. Sifuri toa sifa ni **6**. Hasi 6 toa chanya 3…. ni …. hasi 3…

What are the answers for ?

0 – 6 = ?
– 6 + 3 = ?
– 6 – 3 = ?
– 5 – (– 3) = ?

He! Bwana. HAPANA! Umesahau kitu!

Ukitumia *mstari wa namba*, utaelewa kwa uraisi.

(A) 0 – 6 = ? *Sifuri **toa** 6… which one is correct?*

(a) 0 – 6 = 0, (b) 0 – 6 = 6, (c) 0 – 6 = – 6, (d) 0 – 6 ⇒ impossible

0 - 6 inamaana…

*Ukiangalia upande wa (–), **tembea mbele** kutoka **0** hatua 6 hadi – 6.*

Kwanza niko 0. Naangalia upande wa +.

*Kwa kutoa 6… **geuka upande.***

Tendo 0 – 6 ni sio 0 au 6, wala haiwezekani. Tendo hili linawezekana !

Therefore, the answer is

0 – 6 = – 6

(B) – 6 + 3 = ? *Hasi 6 **jumulisha** 3…..which one is correct?*

(a) – 6 + 3 = 3, (b) – 6 + 3 = – 3, (c) – 6 + 3 = – 9

*Halafu kujumlisha 3, kwa maana… **tembea mbele** hatua 3 hadi – 3.*

Mwisho nitafika – 3.

Mwanzoni niko 0.

*Kwanza kwa – 6, **kurudi kinyumenyume** kutoka **0** kwa hatua 6 hadi – 6.*

– 6 + 3 = ni tofauti na – (6 + 3) =.

Kwa hiyo... – 6 + 3 = – 9 ni ***kosa***.

Therefore, the answer is

– 6 + 3 = – 3

1

(C) – 6 – 3 = ? *Hasi 6 **toa** (chanya) 3…which one is correct?*

(a) – 6 – 3 = – 3, (b) – 6 – 3 = 3, (c) – 6 – 3 = – 9

*Harafu, kutoa 3, **geuka upande** na **tembea mbele** hatua 3 hadi – 9*

*Kwanza kwa – 6, **rudi kinyumenyume** kutoka **0** hatua 6 hadi – 6.*

Mwanzoni niko 0.

– 6 – 3 = ni sawa sawa na – 6 + (– 3) =

Wazo ingine kwa – 6 – 3 = – 6 + (– 3) =

Therefore, the answer is

– 6 – 3 = – 9

Muhimu

Sasa angalia! ***Toa*** na ***Hasi*** ni tofauti.

On the number line

- ***Subtraction (kutoa)** is to change the direction (**geuka upande**).*
- ***Negative (hasi)** means to move backward (**rudi kinyumenyume**).*

Sawa sawa.

(D) – 5 – (– 3) = ? *Hasi 5 **toa** **hasi** 3…which one is correct?*

(a) – 5 – (– 3) = – 2, (b) – 5 – (– 3) = – 8, (c) – 5 – (– 3) = 8

*Kwa - 5, nita**rudi kinyumenyume** kutoka **0** hatua 5 hadi – 5.*

Mwanzoni niko 0.

*Nikifika – 5, **nitageuka upande.***

*Halafu **nitarudi kinyumenyume** hatua 3 hadi – 2.*

Mwishoni, nitafika – 2.

– 5 – (– 3) = ni sawa sawa na – 5 + 3 =

Lakini tena usifanye ***kosa*** kama – 5 + 3 = – 8

Urudie (B) – 6 + 3 = ?

Therefore, the answer is

– 5 – (– 3) = – 2

2

2. BODMAS (MAGAZIJUTO)

Many students make mistakes for the questions below.

MAGAZIJUTO.... mabano, gawa, zidisha, jumlisha na toa.....

What are the answers for ?

– (4 – 7) = ?
– (5 × 2) = ?
8 – 4 × 5 = ?
5 + 2 × 4 = ?

Ndiyo. Lakini, inamaana gani?

- BODMAS (MAGAZIJUTO) indicates the order of arithmetic operations which involve different types of operations and brackets.

Kanuni

Kwanza, fanya tendo lililo ***katika mabono***.
Halafu, fanya tendo la ***kugawa au kuzidisha***.
Mwishoni, fanya tendo la ***kujumlisha au kutoa***.

Hii ni kanuni yake. Lazima kukumbuka kila wakati !!

(A) – (4 – 7) = ? *Hasi ya mabano 4 **toa** 7…. which one is correct?*

(a) – (4 – 7) = – 11, (b) – (4 – 7) = – 3, (c) – (4 – 7) = 3

Ukifanya tendo la ndani ya mabano, itakuwa….
– (4 – 7) = – (– 3)

Therefore, the answer is

– (4 – 7) = 3

(B) – (5×2) = ? *Hasi ya mabano 5 **mara** 2…. which one is correct?*

(a) – (5×2) = 10, (b) – (5×2) = – 10

Unahitaji kufanya tendo la ndani ya mabano kwanza. Kwa hiyo. – (5×2) = – (10)

Therefore, the answer is

– (5×2) = –10

Wanafunzi wengi wanafanya kosa kama.
– (5×2) = – 5×(– 2) = 10
Hii ni ***Kosa***.

Wanachanganya tendo hili na tendo kama
– (6 + 3) = – 6 + (– 3) = – 9
Hii ni ***Sawa***.

(C) 8 – (4×5) = ? *Which one is correct?*

(a) 8 – (4×5) = 20, (b) 8 – (4×5) = 12, (c) 8 – (4×5) = – 12

Unahitaji kufanya tendo la ndani ya mabano kwanza. Kwa hiyo. 8 – (4×5) = 8 – (20)

Therefore, the answer is

8 – (4×5) = –12

3

Umeshaelewa ? Sasa tufanye mazoezi

Exercise

Sawa Mzee!

1	– 7 + 3 =		21	3 + 2 × 4 =	
2	– 6 – (– 2) =		22	– 5 – 2 =	
3	– 6 – 3 =		23	– 2 – (– 5) =	
4	– (7 × 3) =		24	4 – 2 × 5 =	
5	0 – 6 =		25	4 – 8 =	
6	3 – 5 × 2 =		26	– (3 × 5) =	
7	– (4 – 7) =		27	– (2 – 8) =	
8	– 3 + 6		28	– 5 + 2 =	
9	– (8 – 2) =		29	5 + (– 2) × 3 =	
10	6 + 4 × (– 2) =		30	2 + (– 7) =	
11	– (3 – 5) =		31	– 9 – (– 5) =	
12	– 9 – 3 =		32	– 6 + 4 =	
13	– 8 + 2 =		33	8 – 3 × 2 =	
14	– 6 × (5 – 3) =		34	– (6 – 3) =	
15	– 5 – (– 3) =		35	0 – 4 =	
16	0 – (– 3) =		36	5 × (3 – 7) =	
17	6 – 4 × 5 =		37	– 5 – (– 7) =	
18	– 4 + 6 =		38	3 – (– 7) =	
19	(3 – 5) × 4 =		39	– 5 + 9 =	
20	– (6 × 4) =		40	– 5 × (– 4) =	

Answers

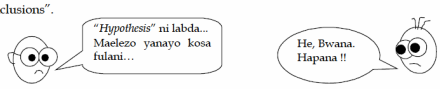
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
- 4	- 4	- 9	- 21	- 6	- 7	3	3	- 6	- 2	2	- 12	- 6	- 12	- 2	3	- 14	2	- 8	-24
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	- 7	3	- 6	- 4	- 15	6	- 3	- 1	- 5	- 4	- 2	2	- 3	- 4	- 20	2	10	4	20

4

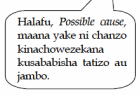
Appendix K: Supplemental teaching/learning material - Biology

Scientific process in Biology

Many Form 1 students did not understand the meaning of the terms "Hypothesis" and "Conclusions".



A "hypothesis" is a tentative explanation for the possible cause of a problem.



1. Scientific research methods

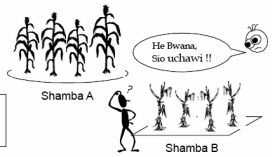
Scientific research involves…

(i) problem identification,
(ii) hypothesis formulation,
(iii) experimentation (observation and data collection),
(iv) interpretation of the data and
(v) drawing conclusion.

2. Example

Situation …

The maize growth in the farm B is not good, while in the farm A the maize grows well.



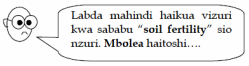
(i) Problem identification

Problem observed
→ *"Poor maize growth in the farm B."*
Formulation of Scientific question
→ *"What is the* ***cause*** *of bad growth?"*

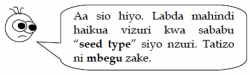
Tatizo gunduwa
→ *Mahindi hayakukua vizuri shamba B.*
Kutoa swali ya kisayansi
→ *Ni kwa sababu gani, hayakukua vizuri?*

(ii) Hypothesis formulation

Hypothesis 1.

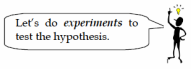


Hypothesis 2.



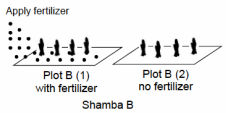
(iii) Experimentation

Experiments should be designed to prove or disprove formulated hypothesis.



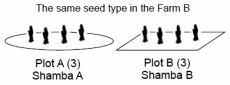
Experiment 1 (to test the hypothesis 1)

Select two plots B(1) and B(2) in the farm B. In plot B(1) apply fertilizers as recommended. In plot B(2) do not apply the fertilizer. The plot B(2) is called the control experiment.
After sometime compare the two plots.



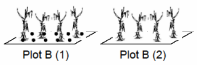
Experiment 2 (to test the hypothesis 2)

Select a plot A(3) in the farm A and another plot B(3) in the farm B. In both plots A(3) and B(3), plant the same seed which was originally planted in the Farm B. The plot B(3) is the control experiment in the Experiment 2.
After sometime compare the two plots in the Farm A and Farm B.



(iv)Result of the experiment and interpretation of the data

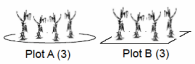
Result of the Experiment 1



Interpretation of the result (data)

Even if the fertilizer is applied to the farm B, the maize does not grow well. It indicates that the soil fertility may not be the cause of the problem of the farm B.

Result of the Experiment 2

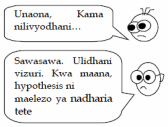


Interpretation of the result (data)

If the seed type in the farm B is planted in the farm A, the maize does not grow well. It indicates that the seed type may be the cause of the problem in the farm B.

(v) Drawing conclusion

- From the experiment 1 and 2, we can say that the "**soil fertility**" is probably not the cause of the poor growth of the maize in the farm B.
- The probable cause is the "**type of seeds**" which was planted in the farm B. → The hypothesis 2 was proved.



3. Exercise Question

Design an experiment to test the hypothesis 3 which says: "The probable cause of poor growth in the farm B was some bacterial disease in the soil in the farm B."

Note

Because a "***hypothesis***" is a tentative explanation, it must be proved or tested by experimentation or by more detailed observation. A "***hypothesis***" must be a testable by experimentation to become a scientifically acceptable explanation.