DEVELOPMENT OF AN INTERACTIVE e-LEARNING MANAGEMENT SYSTEM (e-LMS) FOR TANZANIAN SECONDARY SCHOOLS

Ellen Ambakisye Kalinga

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ABSTRACT

e-learning, as defined to be the use of information and communications technology (ICT) for supporting the educational processes, has motivated Tanzania to apply ICT in its education system. Tanzania secondary schools in rural areas are geographically and socially isolated. Rural Tanzania secondary schools face a number of problems including ways in getting learning materials, as well as inadequacy in qualified teachers. The impact of these problems is poor performance in National Examinations. This poor performance however is highly noted in science and mathematics subjects. The problem in getting learning materials can be reduced by employing ICT in secondary school education system.

This research develops an interactive e-learning management system (e-LMS) to be used by Tanzanian secondary schools. The research is aiming to support teaching and learning functions by allowing creation and storage of learning materials, making them available, easily accessed and sharable among students from different secondary schools in Tanzania in a more organized way. Tanzania has only one curriculum for all secondary schools registered under the Ministry of Education and Vocational Training (MoEVT). During development stage it will not be easy to involve all scattered Tanzanian secondary schools. The research is focusing to two selected pilot schools; Kibaha secondary school and Wali-ul-Asr girls' seminary in Kibaha town, Pwani region. Features of the e-LMS will represent the standard form of any other secondary school registered by the MoEVT. The complete implementation of the e-LMS to these selected pilot schools will later be extended to all other secondary schools in Tanzania.

The development uses Object-Oriented System Analysis and Design (OOSAD) approach along with the power of modeling as it has been emphasized by Model Driven Architecture (MDA). Unified Modeling Language (UML) is mainly used in both cases. To create an interoperable system, UML is integrated with extensible markup language (XML) during model transformation from e-LMS Platform Independent Model (PIM) to e-LMS Platform Specific Model (PSM). Development will make use of open source software. For context specific development, participatory action research methodology is adopted and the inputs are well presented in developing e-LMS. Customization of open source learning management system (LMS) platforms is employed to help generate a timely solution to e-LMS development. Finally, this thesis also considers the need for replication and mirroring of the database for the purpose of making learning materials highly available to end-users.

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DEDICATION

To my late father Mr. Ambakisye Mwalukasa Kalinga

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ACSEE	:	Advance Certificate of Secondary Education Examination
ADSL	:	Asymmetric Digital Subscriber Line
ADT	:	Abstract Data Types
AICC	:	Aviation Industry CBT Committee
A-Level	:	Advanced Level
ASE	:	Adaptive Server Enterprise
ASP	:	Active Server Page
BTH	:	Blekinge Institute of Technology (Blekinge Teknisca Högskola)
CAM	:	Content Aggregation Model
CBG	:	Chemistry Biology and Geography
CBT	:	Computer-Based Training
CD-ROM	:	Compact Disk – Read Only Memory
CIM	:	Computation Independent Model
CMS	:	Content Management System
CoET	:	College of Engineering and Technology
CPU	:	Central Processing Unit
CRC	:	Class, Responsibility, and Collaborator
CSE	:	Computer and Systems Engineering
CSEE	:	Certificate of Secondary Education Examination
CSS	:	Cascading Style Sheets
DBA	:	Database Administrator
DBMS	:	Database Management System
DLES	:	Distance Learning and Education Services
DTD	:	Document Type Definition
ECA	:	Economics Commerce and Accounting
ECSE	:	Electrical and Computer Systems Engineering
e-LMS	:	e-Learning Management System
EMIS	:	Education Management Information System
ERD	:	Entity Relationship Diagram
FTP	:	File Transfer Protocol
GB	:	Gigabytes
HGL	:	History Geography and Language
HKL	:	History Kiswahili and Language
HTML	:	Hypertext Markup Language
HTTP	:	Hypertext Transfer Protocol
IBM	:	International Business Machines
ICS	:	Information and Computer Studies
ICT	:	Information and Communications Technology
ICT4All	:	Information and Communications Technology for All
IE	:	Internet Explorer
IEEE	:	Institute of Electrical and Electronic Engineers
IICD	:	International Institute for Communication and Development
IIS	:	Internet Information Server
IJSS	:	International Journal of Social Sciences

IMS	:	Instructional Management Systems
IP	:	Internet Protocol
IPSec	:	Internet Protocol Security
IS	:	Information Systems
ISBN	:	International Standard Book Number
ISP	:	Internet Service Provider
IT	:	Information Technology
IXP	:	Internet Exchange Point
JSP	:	JavaServer Pages
Kbps	:	Kilobits Per Second
KSS	:	Kibaha Secondary School
LAMP	:	Linux, Apache, MySQL, PHP
LAN	:	Local Area Network
LCMS	:	Learning Content Management System
LMS	:	Learning Management System
LTSC	:	Learning Technology Standards Committee
MB	:	Megabytes
Mbps	:	Megabits Per Second
MDA	:	Model Driven Architecture
MKUKUTA	:	Mpango wa Kukuza Uchumi na Kuondoa Umasikini Tanzania
MoCT	:	Ministry of Communications and Transport
MoEC	:	Ministry of Education and Culture
MoEVT	:	Ministry of Education and Vocational Training
NECTA	:	National Examinations Council of Tanzania
NGO	:	Non-Governmental Organization
NSGRP	:	National Strategy for Growth and Reduction of Poverty
O-Level	:	Ordinary Level
OMG	:	Object Management Group
OO	:	Object Oriented
OOA	:	Object Oriented Analysis
OOSA&D	:	Object Oriented System Analysis and Design
OS	:	Open Source
OSS	:	Open Source Software
PAR	:	Participatory Action Research
PC	:	Personal Computer
PCB	:	Physics Chemistry and Biology
PCM	:	Physics Chemistry and Mathematics
PHP	:	PHP: Hypertext Preprocessor
PIM	:	Platform Independent Model
PoP	:	Point of Presence
PRA	:	Participatory Rural Appraisal
PSM	:	Platform Specific Model
PSTN	:	Public Switched Telephone Network
RAID	:	Redundant Array of Independent Disks
RDP	:	Rational Development Process
RQ	:	Research Question

RTE	:	Round Trip Engineering
SA	:	Structured Analysis
SAREC	:	Swedish Agency for Research Cooperation
SCO	:	Sharable Content Object
SCORM	:	Sharable Content Object Reference Model
SDLC	:	System Development Life Cycle
SE	:	Software Engineering
SEDP	:	Secondary Education Development Plan
SIDA	:	Swedish International Development Agency
SO	:	Specific Objective
SQL	:	Structured Query Language
TanEdu	:	Tanzania Education
TANESCO	:	Tanzania Electric Supply Company
TCC	:	Tanzania Communication Commission
TCP/IP	:	Transmission Control Protocol/Internet Protocol
TCRA	:	Tanzania Communication Regulatory Authority
TEHAMA	:	Teknolojia ya Habari na Mawasiliano
TIE	:	Tanzania Institute of Education
TTCL	:	Tanzania Telecommunications Company Limited
TZS	:	Tanzanian Shilling
UDSM	:	University of Dar es Salaam
UML	:	Unified Modeling Language
UNCTAD	:	United Nations Conference on Trade and Development
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UNU	:	United Nations University
UNU/IIST	:	United Nations University / International Institute for Software Technology
URL	:	Uniform Resource Locator
URT	:	United Republic of Tanzania
USD	:	United States Dollar
VAT	:	Value Added Tax
VB	:	Visual Basic
VPN	:	Virtual Private Network
W3C	:	World Wide Web Consortium
WAMP	:	Windows, Apache, MySQL, PHP
WAN	:	Wide Area Network
WASET	:	World Academy of Science, Engineering and Technology
WebCT	:	Web Course Tools
WLL	:	Wireless Local Loop
WSIS	:	World Summit on the Information Society
WWW	:	World Wide Web
XHTML	:	Extensible Hypertext Markup Language
XMI	:	XML Metadata Interchange
XML	:	Extensible Markup Language
XSD	:	XML Schema Definition

LIST OF FIGURES

LIST OF TABLES

OVERVIEW OF ICT FOR e-LEARNING PROJECT

There are many initiatives already undertaken to address the issues of ICT in Tanzania, one of them being Sida/SAREC, the department for Research Co-operation (SAREC), within the Swedish International Development Agency (SIDA). Sida/SAREC has taken initiative to carry out regional collaboration ICT surveys covering three countries namely Tanzania, Uganda and Mozambique. Looking at the magnitude of different activities that can be improved by the use of ICT even to rural areas, e-learning for secondary schools in Tanzania was given a high priority to the ongoing ICT research project under the above mentioned programme.

The motivation of selecting e-learning for secondary schools project in Tanzania goes along with the National strategy of reducing poverty in the country. The strategy is named as "National Strategy for Growth and Reduction of Poverty (NSGRP)", commonly referred to by its Kiswahili acronym MKUKUTA – "Mpango wa Kukuza Uchumi na Kuondoa Umasikini Tanzania". Ministry of Education and Culture (MoEC, 2004) in its secondary education development plan (SEDP) final document pointed out that the Government formulated a poverty reduction strategy in year 2000. The strategy is underpinned by the notion that economic growth is a precondition for poverty reduction. In turn, this requires sound economic management, increased investment and improvements in productivity. Expansion of the educational system is at the center of the Government's strategy to both increasing the rate of economic growth and productivity, as well as to ensure that the earnings are more equitably distributed.

United Nations Educational, Scientific and Cultural Organization (UNESCO, 2001) argues that the role of education in poverty eradication is crucial. No country has succeeded if it has not educated its people. Education is not only important in reducing poverty, but it is also a key to wealth creation. Education gives power to people to become more proactive and gain control over their lives. The basic education is one of the keys to empowerment, both for individuals and groups. It is the primary vehicle by which economically and socially marginalized adults and children can lift themselves out of poverty and obtain the means to participate fully in their communities. Poverty is both a cause and an effect of insufficient access to or completion of quality education. One valuable quote for education and poverty presented by the late Julius Nyerere, the first President of the United Republic of Tanzania (URT) during the International Workshop on Education and Poverty Eradication Kampala, Uganda, 30 July to 3 August 2001 is (UNESCO, 2001):

"Education is not a way to escape poverty - It is a way of fighting it."

MoEC (2004) in its SEDP final report states that secondary education apart from being vital for sustainable economic take off in the country, has personal and great social benefits crucial for modernization and development of society as a whole. The overall goal of the plan of SEDP is to increase the proportion of Tanzania youths completing secondary education with acceptable learning outcome. The SEDP plan as well as the

Ministry of Education and Vocational Training (MoEVT) ICT Policy for basic education have some programme areas which are supported by the ICT for e-learning project as follows:

- *Improvement of access;* the goal is to reach 50% cohort participation and transition rate from primary to secondary education by year 2010. One mentioned means to achieve this is by the expansion of open and distance learning.

- *Quality Improvement;* the goal is to raise the pass rate of division I – III, from 36% to 70% and eliminate failures. Some of the strategies mentioned include improvement of school libraries, reviewing the curriculum and enhance quality of examinations and assessment systems.

- *Education Management System Improvement;* the goal is to optimize the use of available resources. One of the strategies to achieve this is to improve access to and use of Education Management Information System (EMIS).

The MoEVT ICT Policy for basic education has the mission of integrating ICT to enhance access, equity, quality and relevance of basic education, while stimulating and improving teaching and life long learning (MoEVT, 2007). Along side, the strategy of poverty reduction by employing the use of ICT is being indicated by the Ministry of Communications and Transport (MoCT), National ICT Policy of Tanzania vision which state that (MoCT, 2003):

> *"By exploiting its unique geographical position, Tanzania becomes a regional hub of ICT infrastructure providing ICT-based solutions that enhance sustainable socio-economic development, which addresses national and regional poverty reduction concerns"*

The ICT for e-learning project to a big extend supports strategies that has been pinpointed by the National ICT policy (MoCT, 2003) which emphasizes the use of ICT-based solutions and the concerned MoEVT ICT Policy which wants to integrate ICT in education. The e-learning project is interested in seeing that the pass rate of secondary schools' students is increasing especially in mathematics and science subjects for the purpose of increasing the number of students who meet the entry qualification to join science subject's related degrees. The overall main objective of the e-learning project is:

> *"To improve the quality of science education in secondary school in the rural areas of Tanzania"*

Strategies of implementing this objective of the project are very much related to the plans as indicated by SEDP and MoEVT ICT Policy for basic education:

- *To establish most suitable and effective connectivity and configuration.* This gives the opportunity of implementing distance learning as indicated by SEDP
- *To develop a context centered platform which includes e-learning content management system using open source software.* This is related to the strategy to

improve access to and use of Education Management Information System (EMIS) as mentioned by SEDP and MoEVT ICT policy

- *To develop local content materials for science and mathematics subjects for self learning environment as per approved National curriculum.* This is related to two of the objectives of the MoEVT, (2007) ICT Policy for basic education namely; to facilitate the development and use of ICT as a pedagogical tool for teaching and learning, and to promote development of local content for basic education
- *To develop access control, authorization tools and applications to manage and secure the platform and the contents.* This is related to one of the objectives of the MoEVT, (2007) ICT Policy for basic education namely; to facilitate the use of ICT as a tool for assessment and evaluation of education, as well as administration and management

Internationally, Tanzania like any other country has to abide with the international strategies towards the use of ICT. The e-learning research project is supporting the statement delivered by Kobsak Chutikul on-behalf of Supachai Panitchpakdi, Secretary-General of United Nations Conference on Trade and Development (UNCTAD) at the World Summit on the Information Society (WSIS), ICT for All (ICT4All) in Tunis – Africa (**Chutikul, 2006)**, hereby quoted that:

> *"Information and communication technologies can make a potentially significant contribution to sustainable social and economic development".*

The ICT for e-learning project insist that the key for social and economic sustainability can be easily implemented if people are well educated.

1.0 GENERAL INTRODUCTION

1.1 INTRODUCTION

Information and Communications Technology (ICT) have been integrated in education in many developing and developed countries alike, but the use of ICT in Tanzanian secondary schools is still lagging behind. Many Tanzanian secondary schools have no computers; however many show an effort of acquiring personal computers (PCs). The few schools with computers use them primarily for secretarial services and computer literacy training. Very few secondary schools have Internet services, and they are mainly accessible to the heads of the computer unit, headmasters of the schools and staff. Few schools have ICT infrastructure; that is, a Local Area Network (LAN).

This research comes at a time when there are many initiatives already undertaken to address the ICT issues in Tanzania, however many of them are concentrated in big cities and towns especially in higher learning institutions. Sida/SAREC, the department for Research Co-operation (SAREC), within the Swedish International Development Agency (SIDA) has taken initiative to carry out countrywide ICT surveys that include: Information regarding key ratios, connectivity, access, the human resource situation, key institutions, policy and regulatory framework. The ICT surveys have been undertaken in Tanzania, Rwanda, Uganda and Mozambique (Miller, 2001). In Tanzania this research is conducted at the Faculty of Electrical and Computer Systems (ECSE), College of Engineering and Technology (CoET) of the University of Dar-es-Salaam (UDSM). I happen to be a staff member (Lecturer) of ECSE, CoET and now taking part as a PhD student within Sida/SAREC programme (Research proposal, 2001).

Looking at the magnitude of different activities that can be improved by the use of ICT for rural areas, e-learning for secondary schools in Tanzania was given a high priority to the ongoing ICT research project under the above mentioned programme. It is envisaged that once network connectivity is established in secondary schools, the other services such as e-governance, e-health and e-business can be extended to the surrounding areas. (Research proposal, 2001).

1.2 STATEMENT OF THE PROBLEM

Tanzania secondary schools that are dominantly located in rural areas are geographically and socially isolated. These schools face a number of problems in ensuring quality delivery of learning materials. Such schools face three critical issues that are global in perspective, but remain focused on learners' needs. These are: shortage of teachers, quality of teaching and the capacity of schools in terms of incentives/motivations. Schools located in remote areas are a disincentive for excellent teachers compared to working in urban areas.

The Government is working hard not only to raise quality of education but also to expand access. The Government efforts include programs to raise standards of teachers on part, provide additional funding for high level training up to degree level and in service training. Government efforts cannot have desired impact if even motivated teachers cannot have access to basic academic resource materials for themselves and their students.

Together with the efforts which may be taken by the Tanzania Government towards improving education system, still the rate of increase of newly opened secondary school and students is high compared to the rate of increase of teachers, text books and learning references.

National Data (2004) shows that the total number of secondary schools (Government and non-Government) is almost doubled between 1995 and 2004 as shown in table 1.1. That is from 595 schools in 1995 to 1,291 schools in 2004, an increase of 117%. As a result, student's enrolment has also increased by 120% from 196,375 students in year 1995 to 432,599 students in year 2004. But the total number of teachers has increased by only 68% from 11,158 teachers in 1995 to 18,754 teachers in 2004. Due to this student increased rate, the teacher to students' ratio has increased from 1:17 in 1995 to 1:23 in 2004. Table 1.2 shows the Enrolment of Students and Teacher, and Teacher to Student ratio 1995 – 2004.

Table 1.1: Number of Secondary Schools 1995 – 2004

YEAR	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Govt. Schools	259	303	350	406	444	527	528	599	649	828
Non-Govt. School	339	353	371	375	382	400	409	425	434	463
Total Schools	595	656	721	781	826	927	937	1024	1083	1291
% Increase	-	10	10	8	6	12	1	9	6	19

Source: Basic Statistics in Education from [1]Ministry of Education and Culture, 1995 - 2004

Table 1.2: Enrolment of Students and Teacher, and Teacher to Students Ratio 1995 - 2004

Total Enrolment	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Form I-IV	183659	185119	207560	208738	225866	238194	264892	296529	319487	401598
% Increase	-	1	12	1	8	6	11	12	8	26
Form V-VI	12716	13974	18047	18165	21713	23702	24807	26789	25954	31001
% Increase	-	10	29	1	20	9	5	8	-3	19
Teaching Staff	11158	11689	11434	11691	12783	13470	14352	15837	16399	18754
% Increase	-	5	-2	2	9	5	7	10	4	14
Teacher/ Student ratio	1:17	1:17	1:20	1:19	1:19	1:20	1:20	1:20	1:21	1:23

Source: Basic Statistics in Education from Ministry of Education and Culture, 1995 - 2004

[1] Ministry of Education and Culture is currently known as Ministry of Education and Vocational Training (MoEVT)

Number of secondary schools keeps on increasing year after year. In year 2006 the statistic shows that there were a total of 2,292 secondary schools, an increase of almost 78% of 1,291 secondary schools in year 2004.

Many schools lack basic information resources such as well-stocked school libraries. Textbooks and other reference materials are usually not available in libraries and if available they are outdated. Purchasing textbooks is considerably expensive. Another problem is in inadequacy of laboratory facilities especially for science subjects which lead to newly established schools follow arts curriculum. The result of this is a relatively decreased number of graduate science students and majority of them have poor performance. There are regional schools that do not attract better teachers because of their location, pay scale, competition from private industry, or sometimes because the teachers they need are not available.

These problems cause inequality in performance levels between rural and urban schools as it is being analyzed in sub-item 1.2.2. The result of it is poor performance academically in rural secondary schools. The poor performance is more critical in science and mathematics subjects. Many students do not meet entry requirements for science and engineering courses at higher learning institutions.

1.2.1 Definition of Rural Secondary School

There is no single definition of rural area; however, many definitions tend to identify rural areas as having low population densities and unique economic and social conditions. When coming to rural schools, Sandra et al. (2007) and Sher (1983) state that rural schools have recognizable tendencies, such as: less specialization, less equipment and less bureaucracy than schools in non-rural sites. The distinction between rural and urban has been based on the availability and impact of science and technology. On the negative side, it is imagined that the rural schools offers the students a deficit education due to issues such as lack of science activities (Stine, 1997) and lack of consistent curriculum (Amaral et al., 2001). For the teachers, this deficit model of rural-ness includes geographical isolation (Amaral et al., 2001)

As stated earlier, Tanzania rural secondary schools are generally those schools located in rural areas and they are geographically and socially isolated. But in reality, Tanzania as a developing country, many of its secondary schools both in urban, semi-urban and rural areas are subjected to basic problem mentioned in 1.2 above. Tanzania has many schools located in urban or semi-urban areas but equally facing the same problem as in rural area schools. In this case the definition of rural secondary school with respect to this research is hereby defined as:

> *"Tanzania secondary school whether located in urban area (big cities), semi-urban area (regional and some few district cities) or real rural area with reference to geographical isolation, as long as it is lacking necessary resources such as books, qualified teachers, laboratories etc for the*

purpose of achieving good performance, the school will be referred to as a rural secondary school."

1.2.2 Student's Performance Analysis 1995-2003

Tanzania secondary education system which is the level just after primary school level, is divided into two main parts: One; Ordinary level (O-Level) secondary school which starts from form I to form IV. In form IV, students sit for National Examination famously known as Certificate of Secondary Education Examination (CSEE). Students from O-level can be selected to join advanced level of secondary school or certificate courses depending on the student's performance. Two; Advanced Level (A-Level) secondary school which starts from form V to form VI. In form VI, students sit for National Examination famously known as Advance Certificate of Secondary Education Examination (ACSEE). Students from A-level can be selected to join ordinary diploma courses, advanced diploma courses or first degree university courses depending on the student's performance.

Table 1.3 and figure 1.1 shows the performance of O-Level students in form IV CSEE National Examination as per Basic Statistics of National Data (2004) of the MoEVT between year 1995 and year 2003. The statistics show that students who obtained division I – division III ranges from 23% to 38% only while those who obtained division IV and division 0 ranges from 62% to 77%. Students with division I – division III are considered to have passed their examination and are the possible candidates to be selected to join either form VI (i.e. A-Level) or certificate courses.

Table 1.3: Form IV National Examination (CSEE) Performance in Percentage 1995 – 2003

Division Obtained	**Year**								
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
I – III in %	25	23	30	29	29	26	28	36	38
IV and 0 in (%)	75	77	70	71	71	74	72	64	62
Total Students Examined	37,850	40,479	41,867	42,887	44,172	47389	50,820	49,512	62,359

Source: Basic Statistics in Education from MoEC, 1995 - 2004

When we consider science (Physics, Chemistry and Biology) and mathematics (advanced mathematics) subjects for A-level secondary school students between year 1999 and 2004, we can see that students who obtained A, B and C grades ranges from 14% to 30% for physics, 13% to 23% for chemistry, 10% to 30% for biology and 19% to 39% for advanced mathematics. Performance evaluation using grading system is ranking 'A' to be the excellent pass while the value is respectively dropping to 'B', 'C', 'D', 'E' and 'F'. 'F' is ranked to be completely failure. I am grouping students with 'A', 'B' and 'C' to be the ones who have greater chance of being selected to join university degree courses or any other higher institutional courses. So far, the percentage of the best performance is

not satisfying. Table 1.4 shows the ACSEE students performance starting from year 1999 to year 2004.

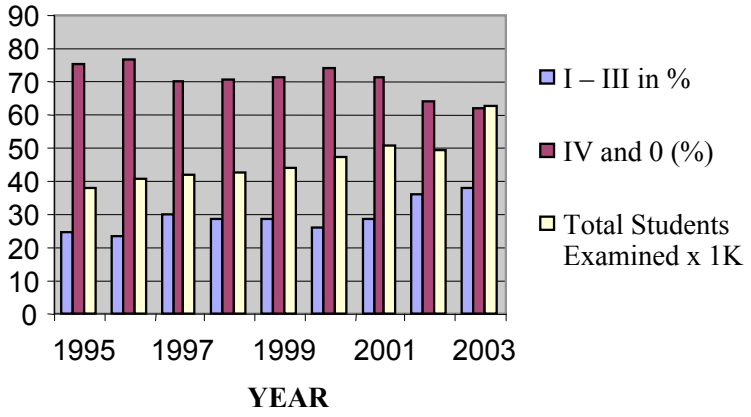

Fig. 1.1: CSEE Student Performance 1995-2003

Table 1.4: Form VI National Examination (ACSEE) Performance Using Grading System

Subject	Pass Grade	Year					
		1999	**2000**	**2001**	**2002**	**2003**	**2004**
Physics	Grades A, B, and C in %	30	14	14	19	17	19
	Grades D, E and F in %	70	86	86	81	83	81
	Total Students Examined	2,480	2,580	2,947	3,154	3,300	3,534
Chemistry	Grades A, B, and C in %	14	16	13	23	23	20
	Grades D, E and F in %	86	84	87	77	77	80
	Total Students Examined	2,219	2,882	3,107	3,481	3636	4,121
Biology	Grades A, B, and C in %	10	23	27	21	18	30
	Grades D, E and F in %	90	77	73	79	82	70
	Total Students Examined	1,628	1,901	2,194	2,309	2,313	2,843
Advanced Mathematics	Grades A, B, and C in %	24	21	22	19	23	39
	Grades D, E and F in %	76	79	78	81	77	61
	Total Students Examined	1,547	2,065	2,102	2,288	2,499	

Source: Basic Statistics in Education from Ministry of Education and Culture, 1995 - 2004

With the poor performance observed in tables 1.3 and 1.4, statistics show that secondary schools in urban areas are highly ranked compared to those in rural areas as shown in table 1.5. Taking one urban area; Dar es Salaam, and two semi-urban areas Mbeya and Iringa as samples, we can see that in Dar es Salaam city many of its schools are ranked up to 100th out of 1080 O-Level secondary schools which sat for CSEE examination in 2004, while Mbeya and Iringa regions schools are below those in Dar es Salaam, except for few privately owned schools.

Table 1.5: Ranking of Urban and Rural Areas O-Level Secondary Schools in 2004 CSEE Examination

Region	Owner	Name of Secondary School	Division					Total Students Examined	Rank (out of 1080 schools)
			I	II	III	IV	0		
Dar es Salaam (Urban Area)	Private	Mzizima	57	16	52	8	0	133	16
		Loyola	47	29	50	4	0	130	18
		St. Antony	65	66	90	24	0	245	28
	Government	Azania	86	102	130	120	7	445	59
		Jangwani	29	61	96	78	1	265	82
		Kibasila	30	37	80	75	1	223	92
Iringa Region (rural Area)	Private	Ruaha	5	17	50	23	0	95	103
		Highlands	9	9	68	23	0	109	98
	Government	Ifunda Technical	51	28	31	36	1	147	35
		Lugalo	28	37	72	65	1	194	106
		Iringa girls'	1	11	39	20	0	71	124
		Tosamaganga	11	21	44	57	4	137	132
Mbeya Region (rural Area)	Private	Sangu	4	20	60	65	0	149	155
		St. Francis Girls'	72	9	3	0	0	84	3
		Meta	3	6	53	64	1	127	205
	Government	Loleza Girls'	7	6	34	39	0	86	145
		Iyunga	65	43	43	51	4	206	40
		Mbeya	46	84	80	82	5	297	68

Source: Examination Results Statistics from NECTA, 1995 - 2004

There are several reasons to find a semi-urban or rural school highly ranked. Reasons including:

- Seminary (mission-run) secondary schools; normally these schools get assistance from missionaries. St. Francis Girls' secondary school in Mbeya region is a missionary owned school
- Government special schools; top ranked students are being grouped together in identified schools and are provided with special facilities. Ifunda Technical secondary school in Iringa region and Iyunga secondary school in Mbeya region are special schools under this Government programme
- Deliberate selection of highly ranked students (cream of students); these schools do not tolerate failures. This is mainly done by private secondary schools. St. Francis Girls' secondary school in Mbeya region is among these schools

Problems for Tanzania secondary schools mentioned were justified by the second survey done in year 2006/2007. The survey is explained in part B of chapter 2: ICT Surveys.

1.2.3 The Need for e-Learning Management System

Recesso (2001) pointed out that, each of the problems to education system has a direct impact on student learning, but it provides broader lens of considering potential use of ICT in education. Like any other developing country, Tanzania education system has to undergo substantial transformation, underscored by the growing application of new information and communications technology. The use of ICT in e-learning and related services has gained commercial significance. The benefits that can be derived from effective utilization of ICT include: cost reduction, performance improvement, quality enhancement and creation of new products and services.

Learning design has the potential to develop e-learning by capturing the process of education, rather than simply content in the form of content objects (learning materials). Leaning involves a number of different users/roles with different ways to participate in the e-learning process. For the creation of distance learning materials to a distributed number of schools, Web-based learning environments are usually being used. Recesso (2001) state that:

> *"Learning Management Systems (LMS) play a central role in the Web-based e-learning scenario. It connects learning contents and learners together in a standardized manner. It manages users, learning materials (in the form of objects in Content Management System (CMS)) and learning events. It manages and administers learning progress and keep track on learning performance. It manages and administers administrative tasks. LMS is a software system designed to facilitate administrative tasks as well as student participation in e-learning materials".*

Some rural secondary schools have acquired their personal computers (PCs) but are not used for teaching of normal subjects. Thus, the research project is on the development of an e-learning management system for Tanzanian secondary schools so as to make use of few available ICT resources to improve teaching and learning functions. The e-LMS to be developed will allow creation, storage, re-use and delivery of digital learning material, and manage these resources and users from central object repository.

1.3 RESEARCH OBJECTIVES

1.3.1 Main Objective

The main objective of this research is to develop an interactive e-learning management system (e-LMS) to be used by Tanzanian secondary schools to support teaching and learning functions.

1.3.2 Specific Objectives

The following are the specific objectives (SO) based on the services to be offered by the e-learning management system:

[2]SO1: To develop a module so as to enable creation, storing, publication and sharing of learning materials
SO2: To develop mechanisms for protecting the database and the information stored, as well as manage users of the system and the workflow of the learning materials
SO3: To develop ways of evaluating students' learning progress through e-LMS, including means of assessment functions

1.4 RESEARCH QUESTIONS

The above specific objectives will be implemented based on the following research question (RQ):

[3]RQ1: How can learning materials content be made available and sharable among several students and teachers?
RQ2: In which ways can the e-LMS database and the information stored inside, including learning materials be secured?
RQ3: How can the e-LMS monitor the learning progress of students, as well as student's understanding to the visited learning materials?

1.5 RESEARCH OUTCOMES

Socially, the developed e-LMS will:

- Encourage collaboration among students, teachers and students/teachers using e-mail regardless of their physical location and time
- Make students and teachers reduce travel time and money that would otherwise be spent on traveling and accommodation expenses when seeking learning materials
- Increase excitement and motivation in learning and
- Encourage students to take responsibility for their learning and hence build self-knowledge and self-confidence

Pedagogically the developed e-LMS will:

- Provide e-Learning teaching and learning materials to secondary school
- Allow students to access and select learning materials as per their level of knowledge, thus, reduce the shortcomings caused by deficiency of books and libraries that are facing majority of Tanzanian secondary schools
- Create equity in access of education resources to secondary schools

[2] SO – Specific Objective
[3] RQ – Research Question

- Allow the MoEVT to easily distribute important information related to education and standardized syllabi for various subjects to secondary schools and
- Allow school administrative activities to be performed in a faster manner

1.6 RESEARCH REGISTRATION

The research involves two higher learning institutions for academic support, the UDSM (Tanzania) and the Blekinge Institute of Technology (BTH – Sweden), where at both institutions I am registered as a PhD student. I am working with the College of Engineering and Technology (CoET) of the UDSM. UDSM is the site, where my research empirical work is taking place. The Division of Technoscience Studies at BTH offers relevant courses needed for the research through the licentiate program. BTH is together with UDSM responsible for the PhD program including the licentiate degree. This is a sandwich program where I spend eight months at UDSM and four months at BTH yearly for the whole research period.

1.7 LIMITATION OF THE STUDY AND RESEARCH FOCUS

e-LMS for Tanzanian secondary schools is aiming at supporting teaching and learning functions of the secondary education system, consequently improve performance of the students. Measuring extent level of support and performance improvement is not a one day job. It requires ample time for the users to adopt and use e-LMS effectively starting from the time installed. This may go beyond my research time limit, hence the need to have the limitation of my study as follows:

- The developed e-LMS will be prototyped for its functioning in a small Local Area Network (LAN) having few computers in a lab, an Apache application server and a MySQL database server.

During development stage it is difficult to involve all Tanzania secondary schools. The focus will involve only few schools, in this case only two secondary schools from Kibaha region are selected. Hence another limitation that:

- The e-LMS system will be installed at UDSM and configured to be used by the selected pilot schools at Kibaha. The two schools which are going to be involved at Kibaha pilot site are Kibaha secondary schools (KSS) and Wali-ul-Asr girls' seminary. e-LMS system will be made fully applicable to these schools, and the objectives of the research will be measured to see if what was intended to be provided by e-LMS is fully covered.

It is possible to use few selected schools because Tanzania has only one curriculum for all secondary schools registered under the Ministry of Education and Vocational Training (MoEVT). Features of the e-LMS will represent the standard form of any other secondary school registered by the MoEVT. The implemented e-LMS to these selected schools will

latter be extended to all other secondary schools in Tanzania. Kibaha as a pilot site is elaborated more in chapter two.

1.8 OUTLINE OF THE THESIS

This thesis consists of 6 chapters apart from an overview of the ICT for e-learning project. ***Chapter one*** gives the general introduction of the research study. It shows the research problem area, the research objectives, research questions, outcomes of the research, limitation of the study and research focus. ***Chapter two*** gives an overview of the ICT surveys conducted. It also shows how pilot site Kibaha is selected. ***Chapter three*** shows the theoretical framework of research methodologies to be applied for this research. This research work stress on using participatory action research (PAR) methodology as a key way to a successful design of the e-LMS system. To create good relationship and sense of trust between the University of Dar es Salaam and secondary schools, students' registration database using Microsoft access database engine has been created and installed in pilot school as an example of participatory work. ***Chapter 4*** covers theoretical review on Web-based technologies. In this case learning-by-doing technique is employed where the designed online bookstore database system is also included as part of the practical application of Web-based technologies. System requirements and specifications for the e-LMS to be developed is explicitly shown in ***Chapter five***. ***Chapter six*** gives concluding remarks, where the final conclusion, main contribution, work done so far and future works are explained. Journal papers are included in ***appendix A***.

2.0 ICT SURVEYS

2.1 INTRODUCTION

ICT for e-learning research project, which is more elaborated in sub-section 2.7.4, is the project conceived at the College of Engineering and Technology (CoET) of the University of Dar-es-Salaam (UDSM). The project is aiming at supporting teaching and learning functions to secondary schools, consequently, improve performance of schools. The ICT project started with a through study conducted by the research group. The aim of this study was to find out the ICT application status of secondary schools and their nearby environment from different regions in Tanzania. Research group included lecturers from the faculty of Electrical and Computer Systems Engineering (ECSE) of the CoET, researchers from faculty of Education, officers from Tanzania Telecommunications Company Limited (TTCL) and PhD students from the University of Dar es Salaam. The survey was conducted in two phases. The entire research group took part in the first phase of the survey in 2004 to be analyzed in Part A below. PhD students took part again in the second phase of survey in 2006/2007 to be analyzed in Part B below. The main purpose of the first survey was to study the level of e-readiness for project implementation. The second survey was for system requirement and analysis, whereby the specifics for the basic needs of the secondary schools' stakeholders were identified.

2.2 MEANS OF DATA COLLECTION

- **Interview**

Open-ended interview questionnaires were prepared and used to interview selected schools' stakeholders (administrators, students and teachers) and organizations officers. Organizations involved were MoEVT, TTCL officers at the head quarters and at regional level as well as Regional/District Education Officers.

- **Physical Observations**

Physical observation on the real status of schools included libraries, laboratories for science subjects, number of teachers and their qualification, presence of computers and/or computer laboratories and their utilization.

- **Existing Documents**

Going through existing relevant documents was the other means of getting more information. Documents include National ICT policy, ICT for basic education and other relevant documents from MoEVT, searched documents from the Internet related to e-learning in Tanzania, other research reports for e-learning in Tanzania, documents from semi-autonomous agencies of MoEVT like National Examinations Council of Tanzania (NECTA) and Tanzania Institute of Education (TIE) etc.

➢ **Participatory Action Research Methodology**

Data collection through interview, physical observation and existing documents were being applied in both surveys (survey one and two). [4]Participatory action research methodology through focus group discussions was the key means of data collection for the second survey. The focus groups were organized as follows:

- With students alone
- With teachers alone
- Joint discussion with students and teachers
- With research members and
- With MoEVT officers

At school level, focus group participants were mainly from those who are closely associated with science and mathematics subjects.

PART A: ICT APPLICATION STATUS IN TANZANIA BY 2004

Ten areas from Tanzania regions and districts were chosen for the survey. A total of 40 schools (at least three – four from each area) were selected, visited and surveyed. These areas were: *Bagamoyo, Iringa, Kibaha, Kilwa, Mkuranga, Moshi, Morogoro, Mwanga, Arumeru* and *Same*. The e-readiness for ICT survey included findings from National ICT policy of Tanzania, MoEVT ICT policy for basic education, data communication service providers, e-readiness at secondary schools in terms of computer availability, availability of necessary infrastructures such as electricity and telephone, e-learning projects for Tanzanian secondary schools which include ICT for e-learning project and finally supportive data from the concerned Ministry of Education and Vocational Training (MoEVT).

2.3 NATIONAL ICT POLICY OF TANZANIA TOWARDS e-LEARNING

Problems facing Tanzania education system have alerted the Government to realize the need of using ICT in education and to take initiative to incorporate e-learning objectives in the National ICT policy. The National ICT Policy of Tanzania (MoCT, 2003) points out that ICT encompasses telecommunications services, computers and associated peripherals, Internet services, e-mail, fax, broadcasting, televisions and other media. One of the objectives of the National ICT Policy of Tanzania is to use ICT to improve the quality of delivery of education and training in all areas including distance learning. Achieving these objectives is however a process – an implementation process with no ready made manuals to follow from the beginning.

The National ICT Policy of Tanzania towards e-learning clearly mentions the following objectives showing its support to the education sector as a whole:

[4] More on participatory action research in chapter 3 "Research Methodology"

- Expand and develop the teaching of ICT at all levels of the National system of formal education, informal education and training
- Expand and improve adult-education, life-long learning and both general and digital literacy programmes, notably for retraining and re-skilling the existing workforce
- Give special attention to providing new learning and ICT access opportunities for women and youth, the disabled and disadvantaged, particularly disenfranchised and illiterate people, in order to address social inequities
- Develop and deploy a nationwide e-education system that support schools, higher education/training facilities across the country by interconnecting them with each other and with relevant knowledge centres, providing curriculum integration while also generating information to better shape policies, strategic plans and tactical decisions for developing education and vocational training in Tanzania

2.4 MoEVT ICT POLICY FOR BASIC EDUCATION

The Ministry of Education and Vocational Training (MoEVT) also believes that the use of ICT in teaching and learning as well as administration and management represents a powerful tool with which to achieve educational and National development objectives. The Ministry has therefore formulated "Policy for Basic Education" to guide the integration of ICT in basic education (MoEVT, 2007). Some of the objectives of ICT Policy for Basic Education related to e-learning are:

- Promote the harmonization of activities, approaches and standards in the educational uses of ICT
- Ensure that there exists equitable access to ICT resources by students, teachers and administrators in all regions and types of educational institutions and offices
- Ensure the proper management and maintenance of ICT resources and tools
- Ensure the organized provision of ICT training to students, teachers and educational administrators
- Facilitate the implementation of communication and information systems for the effective management of the education sector
- Facilitate the use of ICT as a tool for assessment and evaluation of education, as well as administration and management
- Facilitate the use of ICT resources in schools and colleges by the neighboring community
- Facilitate the development and use of ICT as a pedagogical tool for teaching and learning, and for the professional development of teachers, administrators and managers
- Promote development of local content for basic education and other stakeholders

2.5 DATA COMMUNICATION SERVICE PROVIDERS

Eight out of ten surveyed areas show that there is a Point of Presence (PoP) offering dedicated leased circuits (data) over Public Switched Telephone Network (PSTN) from

SIMUNET to clients with bandwidth ranging from 64Kbps to 2Mbps. Areas without PoP are Mkulanga and Kilwa. SIMUNET Company Limited is one of the directorates (departments) in the Tanzania Telecommunications Company Limited (TTCL). In addition to SIMUNET there is an alternative private data provider, SIMBANET offering wireless Internet connectivity to these areas too. With exceptional to two areas Mwanga and Kilwa, Mwanga area is using data connectivity from Moshi town by Wireless Local Loop (WLL) and the available data speeds are: 64kbps, 128kbps, 128kbps, 512kbps and 2Mbps which are shared or dedicated. Kilwa is the only surveyed area which has completely no Internet connectivity.

All areas, except Kilwa, have Internet Service Providers and mobile companies that are operational, providing communication services to complement wired network provided by TTCL. Mobile companies available are Celtel, Vodacom, and Mobile (now Tigo). Twaakyondo et al. (2002) indicates that mobile operators lease backbone transmission capacity (leased line) and interconnect through TTCL.

National wide, TTCL is a Tanzania leading Government affiliated integrated telecommunications company, with a comprehensive portfolio of products and services including local, national and international telecommunications services as well as data communication, internet, and Information Technology (IT) solutions. TTCL offers a wide range of telecommunication services to large corporations and companies, government, diplomatic missions, medium and small business enterprises, residential customers and the general public (Twaakyondo et al., 2002).

TTCL has the most extensive telecommunications network covering all regions in the Tanzania Mainland and the Isles. TTCL data services cover the needs for communication between data nodes in different parts of the network. These include provision of Internet bandwidth and local connectivity between sites in different locations. TTCL data services comprise of the following (TTCL, 2006):

- Broadband
- Internet Bandwidth
- Internet Protocol (IP) Virtual Private Network (VPN)
- Leased Circuits

TTCL delivers Internet based communication services through five broadband packages. Broadband standard is for home and mini-office use at the price of Tanzanian shillings 95 (TZS 95) approximately to United States Dollar 0.08 ([5]USD 0.08) per megabyte (MB), broadband business corporate (10 Gigabyte (GB)) at the price of TZS 360,000 (USD 311) per month, broadband business café (20 GB) at the price of TZS 450,000 (USD 389) per month and broadband hotspot (50 GB) at the price of TZS 1,000,000 (USD 864) per month. All prices include Value Added Tax (VAT) of 20%. There is no restriction as to the number of computers that the customer can connect independent of the product choice ([6]TTCL, 2006). Twaakyondo et al. (2002) adds that TTCL broadband connection service is over a customer's existing TTCL telephone line, using Asymmetric Digital

[5] 1USD = 1157.64 by TZS 30th March 2008 from Bank of Tanzania (BOT): Exchange Rates
[6] TTCL prices are quoted from http://www.ttcl.co.tz as by February, 2008

Subscriber Line (ADSL) technology to separate voice and data signals. Broadband services can be delivered in different ways - over an ordinary telephone line or private network, via a cable connection or wireless networks.

TTCL dedicated Internet bandwidth is a high speed, symmetrical Internet access services for corporate Internet users, Internet Service Providers (ISPs) and business users. The product enables corporate organizations, enterprises and ISPs to gain access to guaranteed Internet bandwidth for high end Web applications in the corporate working environments, for business use and for resale to subscribers (TTCL, 2006). TTCL backbone network has the widest coverage in Tanzania with all regional centers and some districts covered by the Internet Protocol (IP) backbone network through microwave radio links. Currently TTCL is upgrading all regional links utilizing microwave technology to fiber optic technology that will give unmatched reliability, lowest latency and highest possible speed (TTCL, 2006).

TTCL IP Virtual Private Network (VPN) product provides dedicated end-to-end connectivity to link multiple sites through TTCL's IP backbone network. The service offers solution to corporate organizations and enterprises with wide branch network for networking and thus enabling them to seamlessly extend their applications to all branches reliably, securely and efficiently (TTCL, 2006). Prices for IP VPN are as shown in table 2.1.

Table 2.1: Prices for IP VPN as by February, 2008

Speed (Kbps[7])	Initial Price (USD)	Monthly Price (USD)
64	100.00	300.00
128	100.00	500.00
256	100.00	800.00
512	100.00	1,500.00
1024	100.00	2,500.00
2048	100.00	4,800.00

All Prices excluding Value Added Tax (VAT) of 20%
Source: TTCL Web Site http://www.ttcl.co.tz/vpn.asp

Among other services, TTCL also offers a range of digital and analogue private leased circuits capable of carrying voice, data or video traffic. TTCL leased circuits offer constant and permanent access between offices and/or headquarters, between other data/voice service provider's nodes or between their nodes and their customers. Private leased circuits (leased lines) are available in various bandwidths, from 64 Kbps to 2,048 Kbps (2 Mbps[8]) and more as the customer may need. Private leased circuits offered by TTCL have several advantages:

- Private leased circuits are permanently connected, offering instant communication and are leased on a fixed tariff basis, regardless of usage

[7] Kbps – Kilobits per Second
[8] Mbps – Megabits per Second

- Private leased circuit service's bandwidth is dedicated to the connected parties and is not shared or switched, thus providing the best quality of service
- Private leased circuits are also very secure offering security at physical level and hence proven and trusted as compared to the use of public networks
- TTCL private leased circuits are provided over the terrestrial backbone network thus guaranteeing lowest latency

Tariff for leased circuits depend on the distance range from the Internet Exchange Points (IXP). Taking few distance ranges, table 2.2 shows the digital leased line prices per month in USD while installation charges for all leased lines are USD 600.00 (VAT exclusive).

Table 2.2: Digital Leased Lines Prices (USD)/Month (VAT Exclusive)

Distance Range	64Kbps	128Kbps	256Kbps	512Kbps	1Mbps
0-5	150.00	240.00	360.00	600.00	840.00
6-50	232.00	370.00	555.00	925.00	1,295.00
51-100	349.00	558.00	815.00	1,306.00	1,841.00

Source: TTCL Web Site http://www.ttcl.co.tz/leasedcircuits.asp, as by 2008

Yonah (2002) indicates that Tanzania now has over 30 PoPs: Located in over 15 regions - Dar es Salaam, Arusha, Moshi, Tanga, Dodoma, Morogoro, Iringa, Mbeya, Singida, Tabora, Shinyanga, Mwanza, Musoma, Moshi, Mtwara, and Zanzibar.

Apart from having TTCL, Tanzania is now having six more companies licensed by the then Tanzanian Communication Commission (TCC), now Tanzania Communication Regulatory Authority (TCRA) to provide data communication services. These companies include: Wilken Afsat, Datel Tanzania, Equant Tanzania, Simbanet Tanzania, Soft Tech Tanzania and Fastcom Africa. Out of these, Wilken Afsat, Datel and Simbanet appear to be the most active (Miller et al., 2001; Twaakyondo et al., 2002). These companies are permitted to install infrastructure for data communication purposes but not for voice.

2.6 e-READINESS IN TANZANIA SECONDARY SCHOOLS

When looking to the availability of telecommunications services, Internet services, computers and associated peripherals to Tanzania secondary schools, the survey analysis show that at least many of them have acquired computers, either from their own effort by purchasing from their schools' fund or through donors and some from the Government. Due to the high costs, very few schools have managed to acquire Internet service.

Table 2.3 and figure 2.1 show the analysis on availability of computers from 40 surveyed secondary schools taken from ten surveyed areas of Tanzania mainland. From the analysis, it can be seen that only 14 (35%) schools out of forty (40) surveyed secondary schools had no computers. 65% surveyed schools at least had one or more computers, out of which 10 (25%) schools had from one to three computers being used for secretarial

services; 5 (13% approximately) schools had between 4 and 15 computers being used for secretarial services and computer literacy training; and the remaining 11 (27% approximately) schools had more than 16 computers also being used for secretarial services and computer literacy training.

Table 2.3: Number of Computers versus Number of Secondary Schools in Year 2004

Computers availability in schools	Number of Schools	% out of 40 Schools
0	14	35
1 – 3	10	25
4 – 15	5	13
≥16	11	27

Source: Group ICT Survey Reports

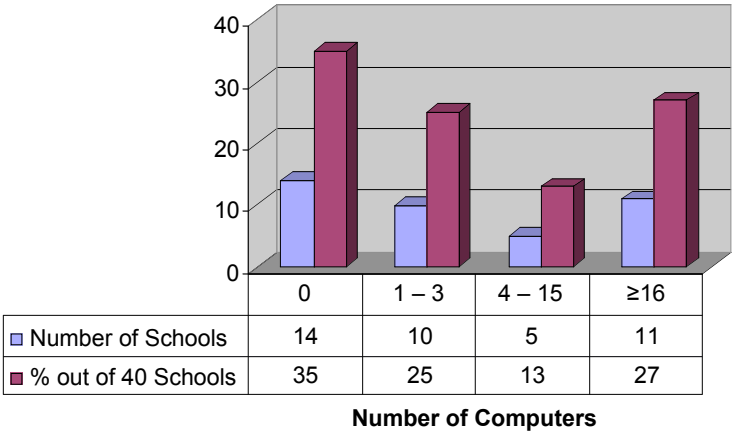

Fig. 2.1: Graphical Representation of Number of Computers versus Number of Schools

It can also be seen from table 2.4 that approximately 10% of 40 surveyed secondary schools had Internet service. Though the Internet service is mainly accessed to the head of computer unit, headmasters/ headmistresses and/or staff, still it is a good start towards the use of ICT in education.

Table 2.4: Number of Schools with Internet Services

Description	Number of Schools	Percentage (%)
With Internet Service	4 Schools	10
Without Internet Service	36 Schools	90

Source: Group ICT Survey Report

Coming to the electrical power availability, 24 schools (85%) out of the 40 schools visited use Tanzania Electric Company Limited (TANESCO) power. 3 schools (7%) use generators for their schools' use. The remaining 3 school had no power. Majority of schools had working telephone facilities. Few of the schools had well secured computer laboratories, and the remaining was ready to construct computer laboratories.

Furthermore issue related to electrical energy is that TANESCO in its Web site "http://www.tanesco.com/" shows the status of electricity in year 2006. Part of the statement says that: "By the end of year 2006, Tanzania Mainland had 21 regions and 113 districts. All the Regional Headquarters so far have electricity. Of the 113 districts, 95 district headquarters have electricity while 18 do not have" (TANESCO, 2006). TANESCO is a parastatal organization created in 1964 and is under the Ministry of Energy and Minerals. The company's core business is to generate, transmit, distribute and sell electricity to customers in Tanzania mainland and bulk supply to the island of Zanzibar.

The adequacy of infrastructures and logistics in schools is a condition to the availability and use of ICT. In this respect Addo (2001) argues that the critical requirements include computers, a school computer laboratory, a school library; electricity, a telephone and security for the safekeeping of expensive computer systems.

2.7 e-LEARNING PROJECTS FOR TANZANIAN SECONDARY SCHOOLS

The effort shown by Tanzania Government to improve teaching and learning is to raise the standard of teachers' preparation programs, increase degree attainment of teachers and increase classroom strategies in service training. The Government is making big effort to improve the situation but is overwhelmed by the rate of the increase of secondary schools and students. Learning resources and teachers are stretched beyond limits. One of several ways to encounter these constrains is to make use of ICT, and below are some of the projects trying to incorporate ICT in learning.

2.7.1 Implementation of IP Based VPN Connectivity in Tanzania

Simba (2005) in her Masters Degree research titled "Implementation of Internet Protocol Virtual Private Network (IP Based VPN) Connectivity in Tanzania", successfully designed and implemented a Wide Area Network (WAN) to interconnect a number of individual secondary schools computer Local Area Networks (LANs) which are geographically dispersed within Tanzania by using the Internet Protocol Security (IPSec) – Virtual Private Network (VPN) technique.

The e-LMS to be developed is a Web-based learning management system aiming to serve a number of distributed secondary schools in different locations. Data exchange and sharing can be performed by computer network systems with Internet service. The e-LMS database will be installed in a centralized server located at the faculty of Electrical

and Computer Systems Engineering (ECSE) of the CoET, University of Dar es Salaam. The e-LMS database will be viewed in a shared manner with all users (stakeholders) of the system using their computers (here referred as clients) which support standard Web browsers. These clients are supposed to be networked to the e-LMS database server.

With Simba's work means that it is possible to incorporate the e-LMS database server in the already developed WAN and make many schools access and use learning materials stored in e-LMS database.

2.7.2 IICD Projects

Efforts in improving secondary education in Tanzania using ICT also show that there are many more projects undertaken by Non-Governmental Organizations (NGO). Like, the International Institute for Communication and Development (IICD) which is an independent non-profit foundation established by the Netherlands Minister for Development Cooperation in 1997. IICD supports many countries with ICT projects including Tanzania. In Tanzania, ICT projects supported by IICD include:

- The project titled "Tanzania Education (TanEdu) Web Site" with the uniform resource locator (URL) http://www.tanedu.org. The aim of this project is to provide timely, accurate and reliable information about education services all over Tanzania. The Web site also includes information about schools' examinations, schools' administration and the latest news in education sector. The news bulletin contains articles targeted to students, teachers and parents (TanEdu newsletter, 2005).

- The Distance Learning and Education Services (DLES) project with the collaboration of Royal Dutch Embassy. DLES in their Web site URL http://www.diles.or.tz, aim in delivering educational materials to secondary schools' students in Tanzania free of charge. Many of the Web sites available are static Web sites and accesses to these Web sites are limited to urban schools' students who have access to Internet cafes.

2.7.3 Projects with MoEVT

The concerned Ministry of Education and Vocational Training (MoEVT) have many planned projects, some already started. One of them is the project titled "ICT Implementation in Teachers' Colleges" (http://www.teachers.or.tz). In August 2005, the Government of the United Republic of Tanzania in collaboration with the Swedish Government through the Swedish International Development Agency (Sida) initiated a project for introducing ICT in all government teachers' colleges. The project's main goal is to improve the quality of pre-service and in-service teacher education by using ICT. It is expected that principals, tutors and students will be trained in ICT to be able to use ICT as a tool for teaching and learning as well as for management and administration (MoEVT, 2007). The MoEVT (2006) in its eSchool programme document state that:

> "Already colleges of education in the country are being provided with ICT facilities so that when teachers graduate they are ICT literate and can use computers for teaching and learning"

ICT Implementation in Teachers' Colleges is a very important project to the ICT for e-learning to Tanzanian secondary schools project. The importance comes in facilitating and enhancing the whole issue towards the use of e-LMS system in secondary schools. We need users to have the knowledge of ICT even in developing stages to make the PAR design easy.

In order to support and implement some of the objectives of the National ICT policy, the MoEVT through its semi-autonomous agency Tanzania Institute of Education (TIE) has developed ICT syllabi for primary and secondary education: Teknolojia ya Habari na Mawasiliano (TEHAMA) for primary schools and Information and Computer Studies (ICS) for secondary schools. TIE is currently finalizing ICT syllabi for teacher education. Two syllabi have been proposed: ICT Academic as a specialization subject and ICT Pedagogy as a compulsory subject for all student teachers (MoEVT, 2007).

2.7.4 ICT for e-Learning Project for Tanzanian Secondary Schools

To complement such mentioned efforts in a more dynamic way, the University of Dar-es-Salaam through its College of Engineering and Technology conceived a research project to develop a tool to enable ICT support rural secondary schools. The focus is to enable ICT support with teaching materials, which are user friendly, facilitating self learning and information sharing, starting with science and mathematics subjects.

The success of this research work is depicted on three basic pillars as shown in figure 2.2. These are "*establishment of suitable and effective connectivity and configuration*", "*development of a context centered platform which includes e-learning management system using open source software*" and "*development of local content materials to self learning environment and sharing*". To minimize operational costs open source platform has been chosen. This research takes part on developing an interactive e-learning management system (shaded area in figure 2.2) for Tanzanian secondary schools.

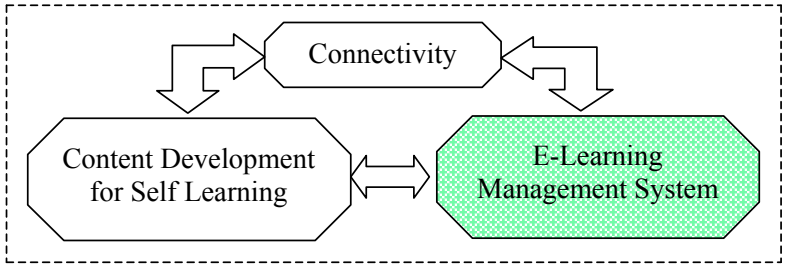

Fig. 2.2: e-Learning Project Components

2.7.4.1 Development of e-LMS

e-Learning is an attentive concept, subject to a wide variation in practice, but which nevertheless has become an established component of education delivery worldwide. Akeroyd (2005) argues that one extreme best use of e-learning is in utilizing the Web technology to facilitate the whole cycle of learning from initial sign-on to final certification, with a range of operations in between, and with no or little, physical interaction among learners. The birth of World Wide Web (WWW) opened up a new dimension to computer based training. WWW enables learners learn online anywhere, anytime and provides possibilities for huge cost savings in corporate training. Online learning has created excellent opportunities to access learning and new ways for collaboration (Akeroyd, 2005).

Watson et al. (2004) argue that the e-learning industry, which includes different groups of users and different knowledge requirements, requires a more manageable system: one, which could monitor the learners' learning, measures it and provide reports on learning efficiency. This requires constant tracking of the learners' actions and results of online tests, and this can be achieved by the use of learning management systems (LMS). LMS provide a technological, parameter driven framework to allow individual academics to develop and deliver learning content, to interact with students and to facilitate open discussion.

Watson et al. (2004) continue to argue that many LMS have been developed to provide a wide range of different features to enable e-learning. All of them aim to deliver four main features: delivery training content, tracking of student performance, management of learning materials and learners, and provision of tools for students' collaboration.

The basic LMS is a Web application where the learner logs on and accesses the learning materials allocated to her/him. While the learner is going through the learning materials repository, the LMS stores information about the learners' interactions, such as scores and answers to the questions. LMS use this information to analyze how well the learner is performing, and is able to provide reports to the administrators and tutors, identifying how well individuals or groups are performing in learning materials or curricula. In this regard, Watson et al. (2004) argue that a LMS commonly contains an interface for managing users, adding/deleting new learners, organizing learners into hierarchy and allocating access rights to users.

2.7.4.2 Kibaha Pilot Site

Tanzania has only one curriculum for all secondary schools registered under the Ministry of Education and Vocational Training (MoEVT), which are majority in Tanzania. During development stage it will not be easy to involve all scattered Tanzania secondary schools. The ICT for e-learning project decided to start with the selected pilot site. The criteria for selecting the pilot site were: accessibility, at least four schools which are nearby, two of them to have both ordinary-level and advanced-level with science subjects and difference

in performance ranking and finally to be of both genders. Kibaha was among the area which happened to suite the mentioned criteria.

Kibaha as shown in figure 2.3 is one of the six districts and the regional headquarters of Pwani region in Tanzania. Kibaha is 40km from Dar es Salaam and easily accessible by road (from Dar es Salaam, about 30-40 minutes drive). Kibaha is supplied with TANESCO National Grid. Most of the Kibaha residents depend on one or more of the following activities for their livelihood: employment, business and agriculture. The community has exposure to ICT through existence of two computer-training centers (Njuweni Hotel and Kaece Computer Centre), Internet cafes and several secretarial shops offering computer-based services. Normal telephone services are easily available.

TTCL regional office has Point of Presence (PoP) offering dedicated leased circuits (data over PSTN) to clients with scalable bandwidth ranging from 64Kbps to 2Mbps. The maximum distance for data connectivity using leased lines is 3-5 km (2 wires). Also there is a wireless option for Internet connectivity via radio links.

In Kibaha area, the survey covered a total of four secondary schools. These are Kibaha Secondary School, Wali-ul-Asr Girls' Seminary, Tumbi Secondary School and Pwani Secondary School, each with quite different level of performance. Kibaha secondary schools and Wali-ul-Asr girls' seminary are the schools selected to be our pilot schools.

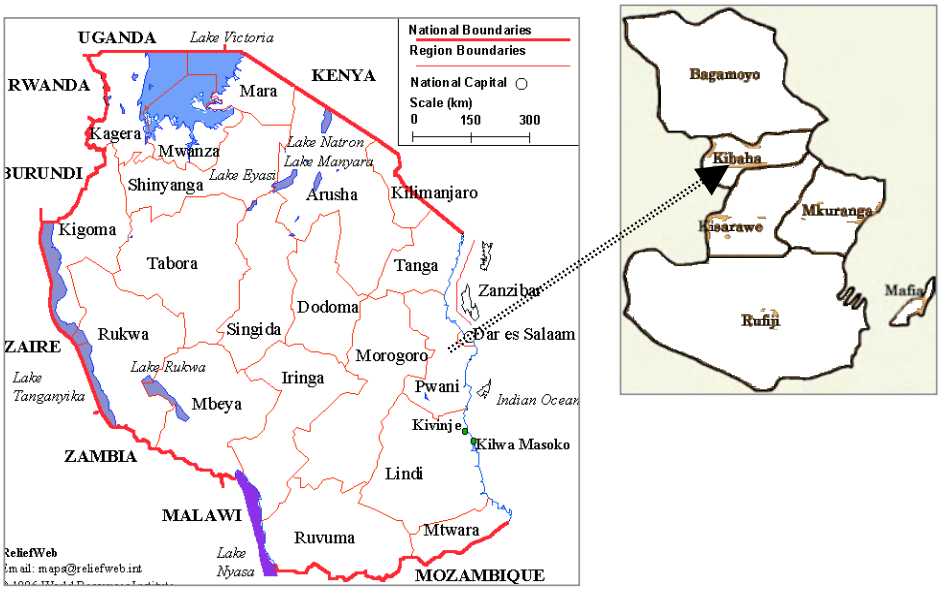

Fig. 2.3: Map of Tanzania Showing Kibaha District in Pwani Region

Apart from many other reasons used to select Kibaha town as a pilot site, the two earmarked schools have quite different motivations which can be used as a challenge in making students share resources from e-LMS system to be developed. Tables 2.5, 2.6 and

2.7 show different status of the two earmarked schools Kibaha secondary school and Wali-ul-Asr girls' seminary.

Table 2.5: Status of Kibaha Secondary School versus Wali-ul-Asr Girls' Seminary 2004

KIBAHA SECONDARY SCHOOL	WALI-UL-ASR GIRLS' SEMINARY
Is a boys' boarding secondary school	Is a girls' boarding secondary school
Owned by the Government	Private owned by World Islamic Propagation
Located about 2.5 km from Kibaha bus stand	Located about 2 km from Kibaha bus stand
School has both 'O-' and 'A-' level offering [9]CBG, PCB, PCM and ECA.	School has both 'O-' and 'A-' Level offering HKL, HGL, ECA and CBG. Planning to add science combinations in future
There are 3 science laboratories, 1 library and one newly rehabilitated computer room	There are 2 science laboratories, 2 libraries and 2 air-conditioned computer rooms.
Four Personal Computers as yet	Has about 20 personal computers (peer to peer networked in one of the computer labs, an Intranet in the administration block) but without Internet connection. The computers are used for both teaching and administrative activities
Teacher to student ratio is 1:17	Teacher to student ratio is 1:15
Nine (9) out of 54 teachers are computer literate	There are four ICT teachers: 1 degree holder, 1 Diploma holder and 2 certificate holders.
One of the National earmarked special secondary school, highly ranked as shown in table 2.6	Poorly ranked as shown in table 2.7
The performance for both O-Level and A-Level is on the high side	Generally, the students' performance for the past three years is moderate

Source: Group ICT Survey Report

Table 2.6: KSS Performance of O-Level Year 2003

Year	**2003**				
Division	**I**	**II**	**III**	**IV**	**0**
Number of Students	35	07	13	06	0
National Ranking	20 out of 754				

[9] CBG: Chemistry, Biology and Geography, PCB: Physics, Chemistry and Biology, CBG: Chemistry, Biology and Geography, HKL: History, Kiswahili and Language, HGL: History, Geography and Language, ECA: Economics, Commerce and Accountancy

Table 2.7: Wali-ul-Asr Performance of O-level Year 2003

Year	2003				
Division	**I**	**II**	**III**	**IV**	**0**
Number of Students	0	1	10	27	1
National Ranking	114 out of 754				

PART B: PROBLEMS JUSTIFICATION BY 2006/2007

2.8 SECOND SURVEY OVERVIEW

The aim of the second survey was to find, identify and substantiate problems facing Tanzanian secondary schools. Solutions on how to overcome identified problems lead to having system requirement for e-LMS to be developed. The survey was done in 2006/2007 and it was a joint survey done by two PhD students Ms. Suzan Lujara and myself (Ms. Ellen Kalinga).

Six areas were selected for this survey, namely Kibaha, Bagamoyo, Songea, Mbeya, Dodoma and Arusha. At least six schools were visited and surveyed in each area. Further more, educational institutions were also visited to find the documented issues concerning Tanzania secondary schools. These institutions include MoEVT and National Examinations Council of Tanzania (NECTA) a semi-autonomous agency of the MoEVT.

For secondary schools, open-ended questioners were designed to get the needed information like; the status of books and reference materials availability, adequacy on teaching staff and how they solve the problem if not adequate, what are the subjects with critical shortage of teaching staff, qualifications of teaching staff, availability of computers at schools, usage of computer if available at schools etc.

2.9 SECOND SURVEY RESULTS

With respect to the main objective of the e-learning project, which states *"To improve the quality of science education in secondary school in the rural areas of Tanzania",* identification of problems for Tanzanian secondary schools education and how to overcome them were obtained through answering three main questions:

- *What are the reasons for poor performance?*
  Reasons for poor performance are clearly identified in chapter one under "statement of the problem" section 1.2. Reasons identified include shortage of teachers, inadequacy of books, references and other basic academic resource materials. These problems are being accelerated by the increased number of schools and students compared to the increased number of teacher and learning resources.

- *To what extent is the poor performance?*
  Extents for poor performance are also clearly stated and analyzed in chapter one under "statement of the problem" section 1.2. Extents considered are results for the National Examination performance, pass grading for mathematics and science subjects (chemistry, physics and biology) in National Examination and ranking of urban secondary schools National Examination performance compared to rural secondary schools.

- *How can students' performance be improved?*
  When e-learning stakeholders were consulted for this, the followings two issues seemed to be the mostly needed by majority of them:
  - The need to have more self learning materials especially in science and mathematics subjects,
  - The need to have a good number of self test questions and past paper examination questions for practice

2.10 DISCUSSION

Tanzanian education system at secondary school level has to undergo substantial transformation, underscored by the growing application of new information and communications technology. The study shows that the country is gradually entering the global information society however the available resources limit the pace considerably. There is a positive trend towards the use of ICT in e-learning in all major parties concerning secondary schools.

The use of ICT provides innovative ways to complement the traditional student-teacher interaction worldwide, to optimize resource usage, sharing and collaboration. Therefore, the development of e-learning facilities for rural areas of Tanzania has high National priorities and hence relevance. Application of ICT in e-learning that is accessible even in remote and rural secondary schools will improve the performance of students in such secondary schools as well as raising morale for teachers and students. The coming chapter gives the research methodology employed to develop e-LMS for Tanzanian secondary schools.

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

There are a lot of results in the field of software engineering concerning the question on how to represent systems and how to build a base for communication between the developer and the user of a software system (Walker et al., 1998). In order to manage the return investment in ICT for education, here referred to e-learning management system (e-LMS), it is essential that the benefits, risks and cost effectiveness of using new technology and new media are well understood in the context of application. An effective approach is to involve users in establishing the expected use of ICT and the benefit of it in education.

The e-LMS to be developed is for Tanzanian secondary schools' members, who many of them are not aware of the ICT technology use in education. Modeling methodology is the best way to create visualization of the system to be defined. With modeling, complex and real-world systems can be somehow understood, qualities of the system can be predicted and communication with stakeholders concerning the key characteristics will be promoted (Brown, 2004). Models are developed as a way of creating a base for implementation of the physical system and testing. Integrating the participatory action research methodology with the whole issue of employing Model-Driven Architecture (MDA) is of significance. Participatory action research methodology and modeling support each other, when it comes to the software development for users.

Methodologies adopted in this research are presented as follows:

- Qualitative research methodology where participatory action research (PAR) methodology is being emphasized. This part also presents the designed student's registration database for Wali-ul-Asr girls' seminary as the starting point of participatory action research methodology and a base of creating good relationship and sense of trust between the University of Dar es Salaam and secondary schools. Wali-ul-Asr girls' seminary is one of the schools from the selected pilot site – Kibaha.
- Software development methodology where object oriented system analysis and design (OOSA&D) approach with the Unified Modeling Language (UML) are employed.
- Model Driven Architecture which emphasize the power of model in software development.
- Selection and customization of open source learning management system (LMS) platforms will bring the e-LMS to its functionality as per Tanzanian secondary schools' requirement and specification, lastly.
- Mirroring and replication of the database so as to ensure high availability to end users.

Lastly this chapter will discuss on related works with this research work.

3.2 PARTICIPATORY ACTION RESEARCH METHODOLOGY

Research methods can be classified in various ways; main two are quantitative and qualitative. The development of e-LMS will base on qualitative research methods where qualitative data resources include; observation (field work), interview and questioners, documents and texts. There are various qualitative research methods, and the choice of which one to employ is being influenced in the way the researcher collects data. In this research, participatory action research methodology will be applied.

Rowley (2003) says that with participatory action research, action and research proceed concurrently. Participatory action research depends upon a collaborative problem solving relationship between the researcher and the clients which aim to both solve a problem and generate new knowledge. Rowley (2003) elaborates more by quoting the key aspects of Gummessons's (2000) characterization of participatory action research as follows:

- Participatory action research take action
- Participatory action research always involves the two roles of solving the problem (the role of the consultant) and making a contribution to knowledge (the role of a researcher)
- Participatory action research requires interaction and cooperation between researchers and the client personnel
- Participatory action research can include all types of data gathering methods (physical observations, interviews, questioners, focus group discussion, documents and texts)

3.2.1 Participatory Action Research Cycle

The importance of considering users in developing computer systems has been recognized since the 1970s (Abels et al., 1998). Systems development encompasses the complete range of activities involved in the process of analyzing, designing, implementing and maintaining an information system (Hirschheim et al., 1995; Jeremy, 2000). It is here taken as obvious that analysis and design cannot be separated from users social contexts for the purpose of study, and that all social factors that impinge on development are worthy of study, with appropriate research methods. Systems development should be taken to be 'multidimensional social change' (Jeremy, 2000; Lyytinen, 1987). The need for an analytical model for work-oriented information system research and practice comes from the requirement that people doing their everyday tasks and duties should have an opportunity to make an impact on the prospective information systems. Information systems should be developed in their organizational context.

O'Brien (2001) states that participatory action research or sometimes known as participatory research is "learning by doing", that is a group of people identify a problem, do something to resolve it, scrutinize their efforts and if not satisfied, try it again. Walker et al. (1998) also argue that participatory design and continuous business improvement can be brought together in a framework which presents a set of different phases in a cyclic order. In the Nordic countries the "Scandinavian model" was introduced in the

middle of the 80s (Ehn et al., 2000), introducing a participatory approach involving users for context sensitive and robust IT system solutions. Coming closer to a sub Sahara African context the participatory action research conducted in the presented project is more likely linked to participatory rural appraisal (PRA) introduced by Chambers (1997) and Rydhagen (2002).

The participatory action research cycle as proposed by Coghlan et al. (2001) and referred by Rowley (2003) is as shown in figure 3.1. It involves four main stages, with one pre-stage:

- Context and purpose is a pre-stage focused on the establishment of the background for the participatory action research intervention. This stage suggests the necessity of change focusing particularly to external factors and internal forces
- Diagnosing is concerned with the identification of the issues, and therefore, the focus for action. It corresponds to the identification of the primary problems that are the underlying causes of the organization's desire for change. In keeping with the spirit of participatory action research, diagnosis must be a collaborative venture, so that the process commences with a shared understanding of the basis for subsequent action
- Planning action is the stage that is concerned with planning the intervention. This activity specifies organizational actions that should relieve or improve these primary problems. Like diagnosis, planning should be collaborative
- Taking action is the step during which plans are implemented and interventions enacted
- Evaluation action is the step that offers the opportunity to focus on the outcomes of the intervention. Outcomes are evaluated in terms of whether the desired outcome has been achieved, but also in order to assess whether:
  - The original diagnosis was correct
  - The action taken was appropriate

The review in this stage leads into the diagnosis stage of the next cycle of participatory action research.

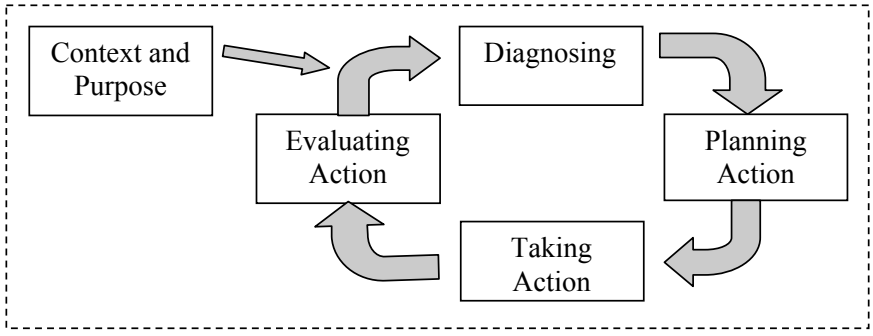

Fig. 3.1: The Participatory Action Research Cycle (Coghlan et al., 2001)

3.2.2 e-LMS with Participatory Action Research Methodology

The knowledge on how ICT and its application can improve social and economical lives of people generally is not very much known to many of the Tanzanian communities. Although, Tanzanian secondary schools may have and be in contact with computers, it doesn't mean that they really understand the impact of ICT if effectively used towards improving performance. Coming to the issue of developing e-LMS for their use, if lack of knowledge is not carefully considered, the utilization motivation of the e-LMS may be very minimal or completely ignored. The emphasis of participatory action research methodology is to be a methodology which accompanies the introduction of technology into organizations and learning. Participatory action research methodology represents a specific form of knowledge generation thus, with participatory action research methodology the understanding of the use of e-LMS will be possible and hence increase assurance towards its utilization in future.

Users mainly students, teachers and school administrators are considered to be the primary source of data. They will be involved in the whole process of developing e-LMS, starting from requirement phase through implementation phase. Means of participatory action research methodology was explained more in chapter two of this research, also presented by Kalinga et al. (2007).

3.2.3 Development of Students' Registration Database System

There are many ICT application activities needed by Tanzanian secondary schools to ensure easy and comfortable daily administrative operations apart from ICT use academically. One area which is being implemented almost manually by many secondary schools is in keeping records for registered students. In order to enable the schools start utilizing the ICT facilities effectively, the project decided also to develop a student registration database system. To start with, only pilot schools were considered. Student registration database designed was for Wali-ul-Asr girls' seminary. The database can suit any secondary school subject to slight modifications as per individual school's requirements. Student's registration database was a joint design of three PhD students namely Ellen A. kalinga (myself), Suzan K. Lujara and Fatuma Simba. To speedup this service, Microsoft Access database engine was used with the support of the Visual Basic (VB) programming. The only reason for selecting Microsoft access was because we were more familiar with the language.

3.2.3.1 Main Objective

To develop a functional database system as per the context of a certain organization depends much more on how end users are involved during the whole process of development. Finding appropriate system requirements depends on how close the developer is to the system stakeholders. Participatory action research methodology as employed by the qualitative research methodology is a key to be closer to the actors.

Naslund (2002) states that qualitative researchers believe that they can get closer to the actor's perspective through detailed interviewing and observation as emphasized to be the techniques adopted by participatory action research methodology. With this regard, student registration database was developed for the purpose of building good relationship and sense of trust between the UDSM and Wali-ul-Asr girls' seminary. For the success of the development of e-LMS, it is very important to be close to end users because they are the ones who to a big extent know what the deficits are in education system and what they really need to improve their performance. Students' registration database system was the starting point to be close to stakeholders of the e-LMS. Students' registration database also introduced me on basics and an overview of designing relational databases using structured approach.

3.2.3.2 Wali-ul-Asr Students' Registration Database

Wali-ul-Asr girls' seminary is a secondary school privately owned by the Muslim Missionary from Iran. The school is getting students from other countries too apart from Tanzania. Records for registered students were partially done using Microsoft Excel where data were transferred from admission/registration form to Microsoft Excel.

Students' Registration database is intended to facilitate easy data record keeping of the registered students as per Wali-ul-Asr context. Information needed for the database was gathered through group discussion with school administrators and concerned personnel participating in recording and keeping data for registered students. To get clearly what information to be gathered before registering a student, source of data also came from admission/registration forms which were used during the process. Information gathered in this form included information for a student as a person, parent/guardian information, disability/allergy and vaccination information, past academic records, fee and sponsorship information and dormitory allocation for borders. Participatory further went on asking reports needed by the school. With this information, the design came up with the entity relationship diagram (ERD) as shown in figure 3.2. ERD was the base for designing the database system.

Input to Wali-ul-Asr Students' Registration Database include information like subject combination, country of residence, dormitories, fee structure, nationality, vaccination, students' particulars, parents/guardian information, application records, accommodation allocation, fee transaction records, form (level of class) allocated, students' sponsor information, presence of certificates, name of the staff entered the information and other useful remarks.

Output reports titles for Wali-ul-Asr Students' Registration Database include overall list of registered students, list of registered students by registration date, student's accommodation, dormitory status, specific student's particulars, list of students based on gender and many other as shown in figure 3.3.

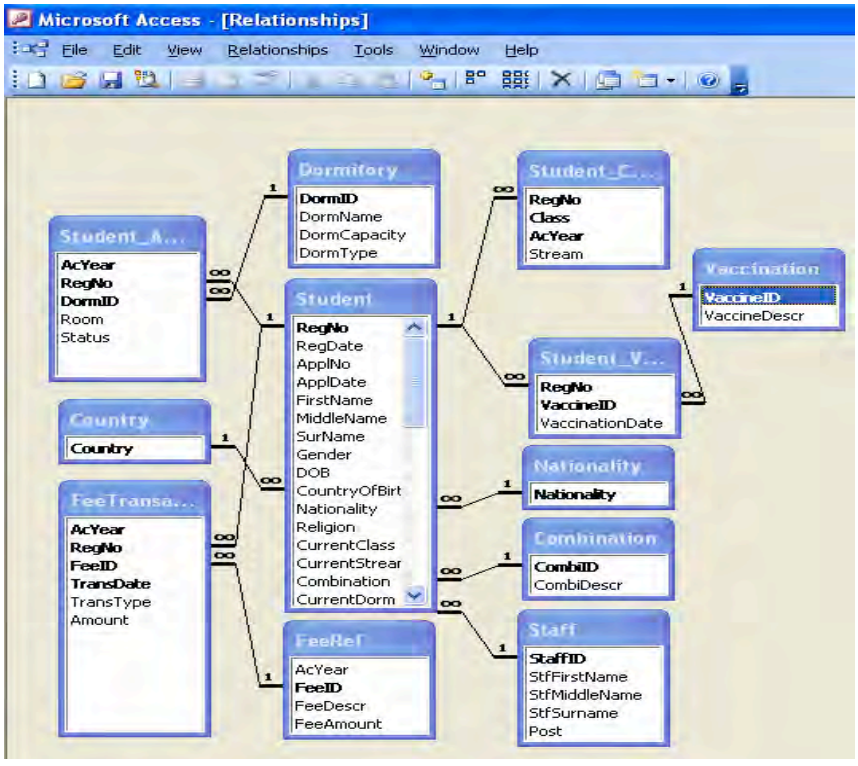

Fig. 3.2: ERD for Students' Registration Database

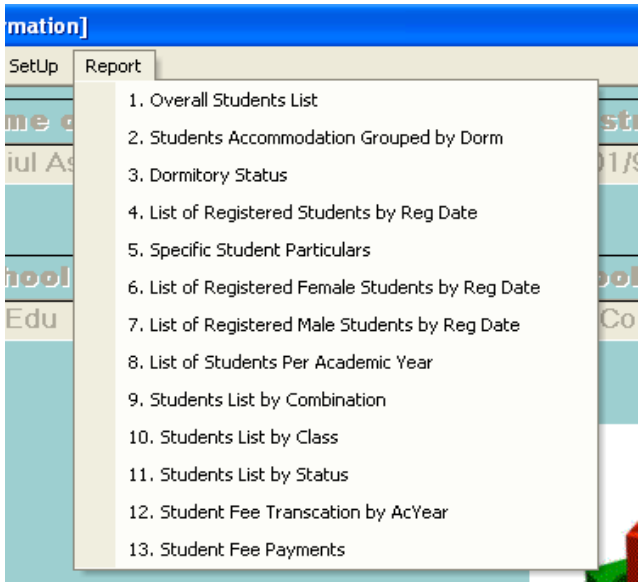

Fig. 3.3: Reports Titles for Students' Registration Database

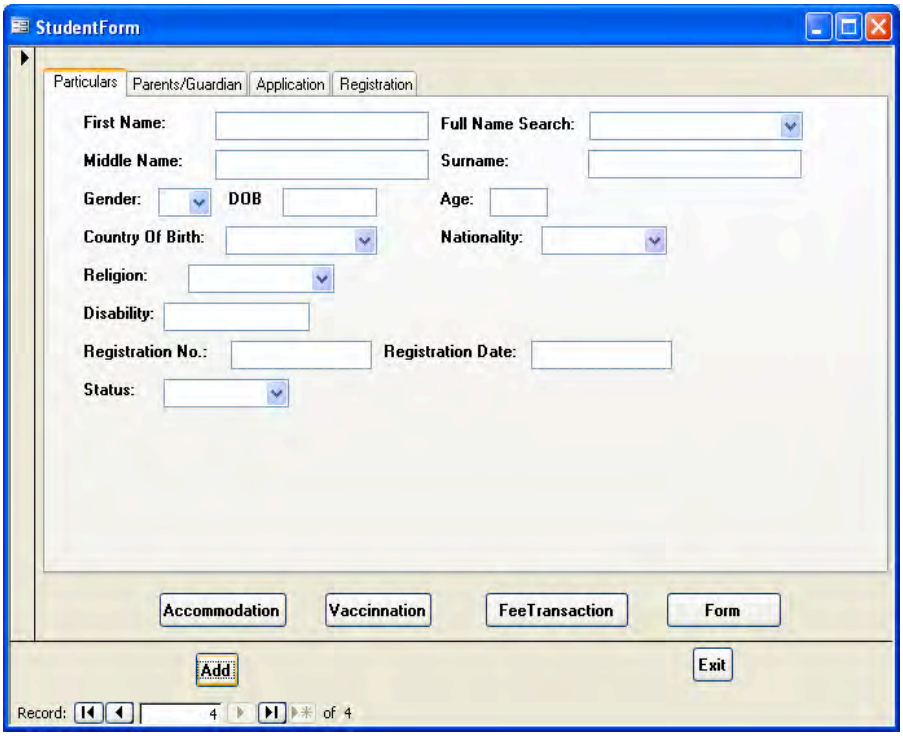

Fig. 3.4.: Student Form

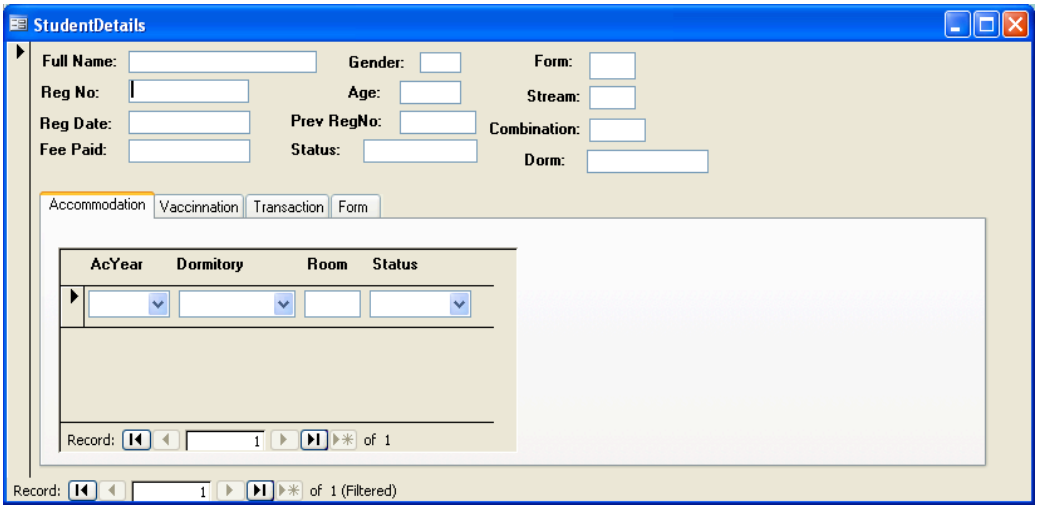

Fig. 3.5: Student Details Form

Data entry is done using interface forms. Figure 3.4 shows *student form* which is embedded with four pages namely particulars, parents/guardian, application and registration. *Student form* also comprises of four command buttons namely accommodation, vaccination, fee transaction and form which facilitate the process of inserting information regarding accommodation, vaccination, fee transaction and form allocation for a selected student respectively. By clicking any of these buttons, a new form called *student details* is opened. To enter information using these buttons can be done either by clicking one button at a time or clicking any button and use the corresponding embedded pages in *student details* form as shown in figure 3.5.

3.3 OBJECT ORIENTED SYSTEM ANALYSIS AND DESIGN

There are several software development methodologies employed. The most commonly applied approaches are structured approach and object oriented (OO) approach.

Yourdon (1991) says that the structured approach has since been reckoned to be the most widely used methodology. Yourdon (1991), Davis (1983) and Kendall (1996), also explain that structured approach prescribes analyzing and designing software system through functional decomposition. It examines an information system in terms of the functions it performs and the data it uses and maintains. Structured approach identifies the major functions or processes of a system, then breaks or decomposes each function down into its smaller composite steps (Davis, 1983; Kendall, 1996). Furthermore, techniques which are invariably present in many methodologies, such as entity relationship diagrams, dataflow diagrams and data dictionaries are also clearly mentioned.

Thomann (1994) indicates that Object-oriented (OO) approach has been identified as the new paradigm for system development. OO decomposes the system down into objects, that is, it examines the system in terms of the components in the system and how these components act and interrelate. The analyst first identifies the objects that comprise the system, then creates an object model which groups the objects into classes, and describes each class in terms of its attributes (or data), methods (or functions) and relationships to other classes (Schach, 2004).

The key idea in object orientation is that: the real world can be accurately described as a collection of objects that interact. An object model includes four components: objects (that is abstract data structures), classes (i.e. abstract data types), inheritance (hierarchical relationships among Abstract Data Types: ADT) and polymorphism by inheritance.

In software development, successful Information System is subject to frequent evaluation and revision within a framework known as System Development Life-Cycle (SDLC). Davis et al. (1988) argue that SDLC is the basic for most software development methodologies. Pressman (1997) adds to this by pointing out that system's life cycle consists of four principal phases:

- *Requirement Phase* as the process whereby the users' needs in a software project are identified modeled and validated. Arayici et al. (2005) comment that this phase is regarded as one of the most important aspects of building an information system because it is during this process that what is to be built is decided. It is an iterative process by which the needs and requirements of individuals and groups significant to the development are researched and identified. Requirements phase defines: customer, user and market requirements; design requirements; and technical requirements.

- *Analysis Phase* as the major information source for design of a new system. It specifies the system objectives and describes the work and its constraints to which designers have to comply.

- *Design Phase* as where architecture is established. The phase starts with requirement documentation delivered by the requirement and analysis phases and maps the requirements into architecture.

- *Testing/Implementation Phase* as where the system is built. The implementation phase deals with issues of quality, performance, baselines, libraries, and debugging. The end deliverable is the product itself.

These phases address what is to be built, how it will be built, building it and increase the quality to highest possible standard.

This research will adopt Object Oriented (OO) approach. Under this approach Booch et al. (2001) argue that the process of object-oriented analysis (OOA) from SDLC is composed of the following activities: requirement capturing, specification component identification, and specification representation. During requirement capturing: several function-viewed notations are used, including context diagram of the structured analysis (SA) technique, use case diagrams and activity diagrams of the unified modeling language (UML). During specification component identification a systematic procedure is provided to identify class and their attributes from data, and to identify class operations from CRC (class, responsibility, and collaborator) cards, and during specification representation most notations used are from UML.

An OOA technique is generally composed of an OOA process to analyze requirements and identify specification components (e.g., classes and class relationships), and an OOA model to represent specifications. UML can be used for OO models in all phases of software development, including OOA. In this connection Chen et al. (2000) say that OOA provides rich notations for representing OO components, such as classes, objects, object behaviors of classes, object interactions and even functions (use cases and activity diagrams).

The UML is the standard language for specifying, visualizing, constructing, and documenting all the components of a software system (OMG, 2003b). With UML, a software system can be described at various levels of granularity (example the system

level, the subsystem level, and the class level.) and from various viewpoints (example the logical view and the use-case view). UML helps to simplify the process of software design, making a model for construction with a number of different views. UML can help in the following ways: aiding understanding of complex systems, exploring and comparing design alternatives at a low cost, forming a foundation for implementation, capturing requirements precisely, communicating decisions unambiguously and is a simplification of reality. UML is also the one adopted by Model Driven Approach (MDA), the one planned to be used in this research.

The e-LMS is a system to be developed hence will abide to System Development Life Cycle (SDLC). SDLC for e-LMS will have:

- System Requirement and Specification phase where use-case diagram will be used
- System Analysis and System Design phase where conceptual, sequence, collaboration, design class and component diagrams will be used
- System Implementation phase where user interface and the application programs (coding) that use and process the database will be designed and implemented
- Testing Phase where the developed system will be tested

3.4 MODEL DRIVEN ARCHITECTURE

Design through modeling, which is a norm in the engineering domains, enforces a careful investigation of the structure, behavior and architecture of a system in the early stages of development and promotes documentation and reuse. Czarnecki et al. (2005) mention that the Object Management Group (OMG) initiative Model Driven Architecture (MDA) attempts to separate application functionality specification from the implementations of that functionality on specific technology platforms. This approach is intended to play a key role in the fields of information system and software engineering. MDA is supposed to provide a basic technical framework for information integration and tool interoperability based on the separation of platform specific models (PSM) from platform independent models (PIM).

MDA guide indicate that PIM represent the functionality and behavior of a system and capture only the application logic. PIM is then converted to PSM, which capture the technology-specific details of a system implementation. The separation of concerns between the application and technical aspects of a system promotes separate, yet, controlled evolution of both aspects of the system based on different needs. The primary goals of MDA are portability, interoperability and reusability through architecture separation of concerns (OMG, 2003a). A key standard in the MDA is based on Unified Modeling Language (UML) as recommended by OMG.

Brown et al. (2005) insist that models provide abstractions of a physical system that allow engineers to reason about that system by ignoring extraneous details while focusing on relevant ones. All forms of engineering rely on models to understand complex, real-world systems. Models are used in many ways: to predict system qualities, reason about

specific properties when aspects of the system are changed, and communicate key system characteristics to various stakeholders. The models may be developed as an originator to implementing the physical system, or they may be derived from an existing system or a system in development as an aid to understanding its behavior.

3.4.1 Different Approaches in Using MDA

There are several ways on how enterprise application developers take advantage of modeling. Brown et al. 2005 illustrate this as shown in figure 3.6, showing the spectrum of modeling approaches in use by software practitioners today. Each category identifies a particular use of models in assisting software practitioners to create running applications (code) for a specific runtime platform, and the relationship between the models and the code.

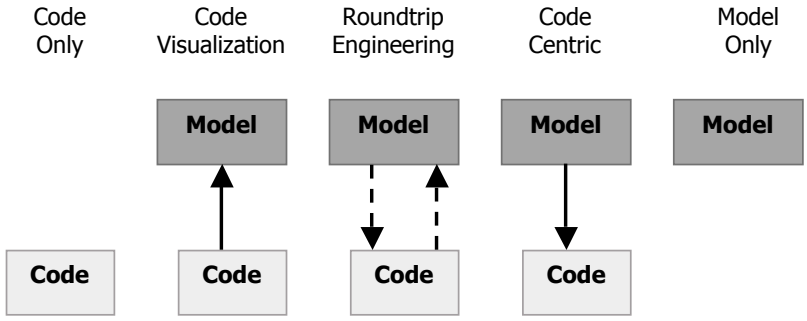

Fig. 3.6: The Modeling Spectrum (Brown et al., 2005)

Left end of the modeling spectrum in figure 3.6 shows a *code-only* approach and do not use separately defined models at all. Software developers rely almost entirely on the code they write, and they express their model of the system they are building directly in a third-generation programming language such as Java, C++, or C#. While this approach may be adequate for individuals and very small teams, it makes difficult to understand key characteristics of the system among the details of the implementation of the business logic. Furthermore, it becomes much more difficult to manage the evolution of these solutions as their scale and complexity increases, as the system evolves over time, or when the original members of the design team are not directly accessible to the team maintaining the system (Brown et al., 2005).

An improvement is to provide *code visualizations* in some appropriate modeling notation. As developers create or analyze an application, they often want to visualize the code through some graphical notation that aids their understanding of the code's structure or behavior. It may also be possible to manipulate the graphical notation as an alternative to editing the text-based code, so that the visual rendering becomes a direct representation of the code. Such rendering is sometimes called a code model, or an implementation model (Brown et al., 2005).

Further modeling advantages are available through *round trip engineering* (RTE), which offers a bi-directional exchange between an abstract model describing the system architecture or design, and the code. The developer typically elaborates the system design to some level of detail, and then creates a first-pass implementation by applying model-to-code transformations, usually manually (Brown et al., 2005).

In a *model-centric* approach, the system models have sufficient detail to enable the generation of a full system implementation from the models themselves. To achieve this, the models may include, for example, representations of the persistent and non-persistent data, business logic, and presentation elements. If there is any integration with legacy data and services, the interfaces to those elements may also need to be modeled. The code generation process may then apply a series of patterns to transform the models to code (Brown et al., 2005).

A *model-only* approach is at the far-right end of the coding/modeling spectrum shown in figure 3.6. In this approach developers use models purely as aids to understand the business or solution domain, or for analyzing the architecture of a proposed solution. Models are frequently used as the basis for discussion, communication, and analysis among teams within a single organization, or across multi-organizational projects. In practice, the implementation of a system, whether from scratch or as an update to an existing solution, may be disconnected from the models (Brown et al., 2005).

Renaux et al. (2005) state that MDA have several benefits, including the following:

- Software programmers/engineers read and understand the application logic easier. That improves group work which is inherent in all software development projects
- As application logic is defined independently from a technological context, it is not subject to frequent technological changes (causes may be platform evolution, economic choices, adoption of technology in fashion) and has a longer life expectancy

3.4.2 MDA with e-LMS

UML is one among the technologies specified by OMG as a language to enable model driven approach. OMG in its UML specification version 1.5, (OMG, 2003b) mentions that UML offers a standard way to write a system's blueprints including conceptual things. Development of e-LMS will base on model driven architecture using UML as a modeling language. Several diagrams will be used to visualize the system for the easy understanding and discussion with end-users and research group. Diagrams to be involved are *'use case'* diagrams in requirement and specification phase, '*conceptual'* '*sequence'*, '*collaboration'*, '*design class'* and '*component*' diagrams in system analysis and system design phase.

As stated earlier, MDA is supposed to provide a basic technical framework for information integration and tool interoperability based on the separation of platform specific models (PSM) from platform independent models (PIM). MDA guide (OMG,

2003a) points out that MDA is a conceptual framework created by OMG that separates business-oriented decisions from platform decisions to allow greater flexibility when architecting and evolving software development and deployment. To support these principles, the OMG has defined a specific set of layers and transformations that provide a conceptual framework and vocabulary of MDA as summarized in figure 3.7. Set of layers defined includes computation independent model (CIM), platform independent model (PIM) and platform specific model (PSM). Along with conceptual framework, OMG through MDA has also provided a set of standards to express models, model relationships and model-to-model transformations (OMG, 2003a).

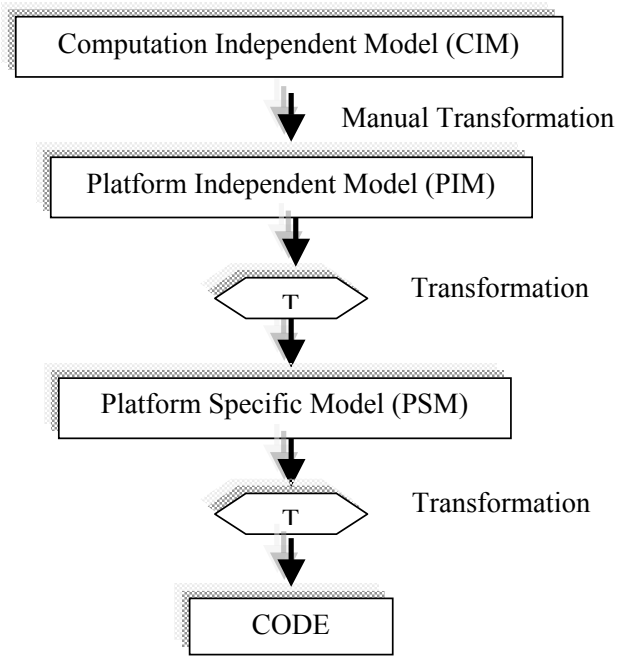

Fig. 3.7: MDA Conceptual Framework

When relating object oriented system analysis and design approach to MDA as shown is figure 3.8, CIM for e-LMS will model the system requirement and specifications. UML will be used to model the user requirements and their boundaries. The e-LMS has considered several users including students, teachers, content administrator, school administrators, system administrator, guest user and officers from the concerned Ministry, here Ministry of Education and Vocational Training (MoEVT). CIM also shows the e-LMS system architecture and standard specification to be employed.

PIM is related to system analysis and system design stage. UML will model e-LMS at different viewpoint levels of abstractions from the platform independent viewpoint. This model will give what is being expected to be provided by e-LMS to Tanzanian secondary schools. At this stage, the structure of the e-LMS database through design class diagram can be used to select the open source LMS platform. The model of that platform will

enable implementation of a system with desired qualities and will promote the nature of mapping towards PSM.

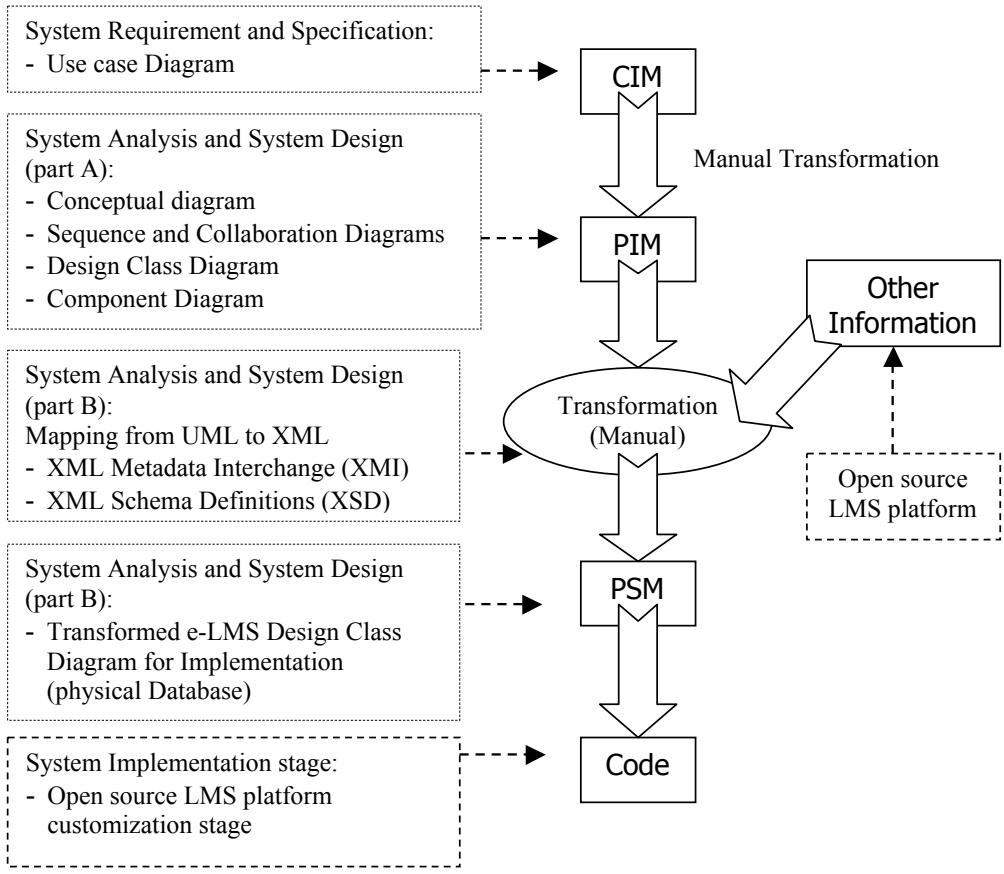

Fig. 3.8: MDA Model-to-Model Transformation

The e-LMS is a Web based platform in order to carter for wide access to a big number of rural secondary schools in different regions of Tanzania. The functionality specified in the PIM will be realized in a PSM through the application of some transformation. The transformation from PIM into PSM will be to express the UML into XML Metadata Interchange (XMI) using standard definitions expressed as XML Schema Definitions (XSD) as shown in figure 3.9.

XMI is an application of Extensible Markup Language (XML), which lends itself to transporting information that is highly internally referential. XMI is applied to transport UML models by generating a special XSD through applying the rules of XMI to the concrete UML metamodel. The general mechanism applied within OMG to transport meta-information is XMI (OMG, 2003a).

Finally, PSM will be mapped to application using interfaces, code and Structured Query Language (SQL queries) adapted from open source LMS platforms as part of system implementation stage.

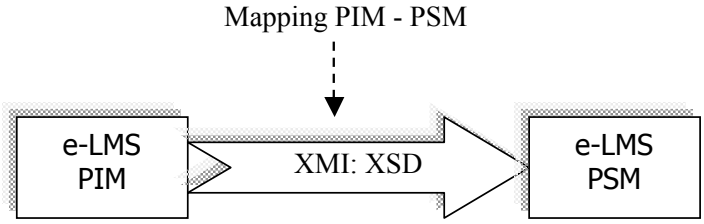

Fig. 3.9: PIM Transformation into PSM

3.5 CUSTOMIZATION OF OPEN SOURCE LMS PLATFORM

Learning Management Systems (LMS) are specialized Learning Technology Systems based on the state-of-the-art Internet and WWW technologies in order to provide education and training following the open and distance learning paradigm (IEEE LTSC, 2001a; IEEE LTSC, 2001b). Moore et al. (1996) and Carlson (1998) argue that the design and implementation of such systems is not an easy task since they are complex systems that incorporate a variety of organizational, administrative, instructional and technological components.

LMS that are in use today are either commercial products (e.g. WebCT, Blackboard), or free open source products (e.g. moodle, claroline), or customized software systems that serve the instructional purposes of particular organizations. LMS that belong to the third category are exponentially increasing, as most education and training institutions are building or planning to build their own LMS. This is due to the fact that a customized LMS will fit better their specific learning purposes, and proves to give a good return of investment over the years (Collier, 2002).

It is obvious that Tanzanian secondary schools can not afford the cost of commercial learning management systems, as well as get hold of a system optionally fitted in the specific context. Further more many free open source LMS are designed to suite higher institutions while we are developing e-LMS for lower level of secondary schools. The alternative means is to customize open source LMS. To ease e-LMS development process and to help generate a timely solution, existing open source LMS platforms will be used. Most open source LMS could support the basic functions we need in developing e-LMS, but there was an obvious need for detailed customization.

3.5.1 Significance of the Open Source Software

Open source software (OSS) can be defined as software that is free in terms of its source code being available, as well as free in terms of purchase charges, and software licensing

(OSS Africa, 2005). OSS source code is freely available to individuals to customize according to their own needs and distribute provided they abide by the accompanying license. This differs from commercial software which may only be obtained by some kind of payment; either by purchasing or by leasing. Open source software is based on open distribution of the source code that forms the software's foundations. This means that any technically competent programmer can examine the inner working of the source code and make changes to the operation of the software. Open source software is typically provided free of charge or for a nominal distribution cost. Some open source licenses require that any change to the source code be redistributed on the same open source license terms as the original source code (Dalziel, 2003).

OSS can be used in educational institutions based on the following advantages:

- Independence from software vendors
- Cost savings; saving on paying license fees, but only pay for support and services that might be needed
- Higher reliability; refer to the absence of bugs causing incorrect operations, which is a result of the source code being freely available and bugs can be fixed immediately (Gbdirect, 2005)
- Higher stability; Stability is achieved through interchange formats that are often quite stable and incompatible file formats not that much of an issue (Gbdirect, 2005)
- Better functionality; can be easily modified based on organization context
- Better performance; OSS is particularly strong in the server and network environments, and hence most advantages are geared towards the use of Linux as an OSS operating system (OSS Africa, 2005)

3.6 e-LMS DATABASE MIRRORING AND REPLICATION

The e-LMS database is for Tanzanian secondary schools' members (students, teachers and school administrators) who are geographically distributed and dispersed in different regions. The e-LMS database server will be centrally placed at the University of Dar-es-Salaam, College of Engineering and Technology. The access of data to the centrally placed database is by the means of network connectivity (Internet) which is not very reliable due to several reasons like the limited bandwidth and/or electrical breakdowns. Amir et al. (2002) reveal that the centralized approach suffers from two major drawbacks:

- Performance problems due to high server load or high communication latency for remote clients
- Availability problems caused by server downtime or lack of connectivity. Clients in portions of the network that are temporarily disconnected from the server cannot be serviced

Lack of connectivity due to several reasons like electrical power failure is common and the major problem in Tanzania. To increase the availability and accessibility of the database, replication of database is of no compromise, and it implements one of the specific objectives of this research, that is to enable publication of learning materials.

Replication is intending to create copies of the database and these copies can be placed to individual school or within the cluster of a number of schools for the purpose of easy sharing of data from the database, across multiple sites. The main reason for replicating in the first place as stated by Thompson (1997) is to enable remote users to continue working even if the connection to the central site is down.

To ensure high availability of learning content from the database, replication will also be supported by mirroring of the database as shown in figure 3.10 so as to overcome the planned and unplanned downtime. Mishra (2006) says that unplanned downtime is primarily caused by hardware failure (computer failure and storage failure), disk corruption, power outages, communication failures, natural disasters, terrorism, human error, and other factors that cause the primary production database, the production server, and/or the production data center to be unavailable. Planned downtime is primarily due to changes that are applied to the production system. These might be hardware upgrades, software upgrades, and database storage and configuration changes, which cause the primary database or server to be unavailable for a short period of time.

Thompson's (1997) analysis found that many of the open source database management system (DBMS) by default provides only the limited master to slave (publisher to subscriber) replication capabilities and setups. Mirroring and replication involves much more than setups. Apart from a thorough understanding of the replication mechanism employed by the DBMS to be used by the e-LMS that is MySQL, it also requires careful analysis and planning before replication implementation. Thompson (1997) emphasizes that all database administration must make sure that the design takes the distributed database into account.

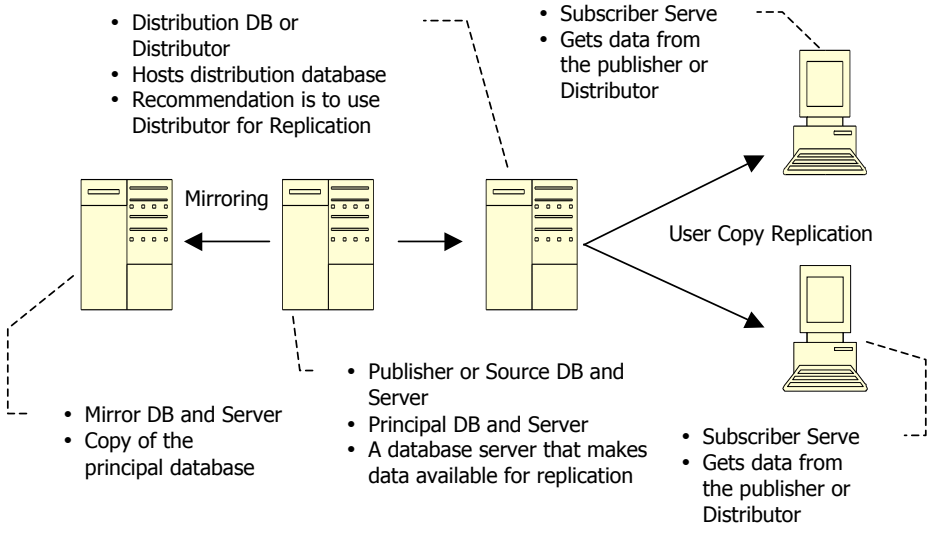

Fig. 3.10: Architecture for Database Mirroring and Replication

3.6.1 Intranet Network in Education

Access through Web browsers mainly Internet Web browsers somehow create doubt on reliability due to limited bandwidth and affordability of the Internet in terms of cost to many people. Replicating database to local servers can just be one part of solution due to reliability as mentioned in e-LMS database mirroring and replication. There are some other options which may take care of the problem. Using Intranet network in education can be a good option to reduce costs and increase reliability. As defined by Kuzic et al. (2006) Intranet is a computer network, based on Internet technology that is designed to meet the internal needs for sharing information within a single organization or company. Intranet supports exclusive sharing of information among a prescribed community of users - typically members of an organization. Kamthan (1998) argues that Intranets in education are most useful to organizations that: are geographically dispersed, share common educational views and objective, have common information/communication needs, value collaboration and are strongly concerned about their information security and privacy.

Kamthan (1998) again mention that there are several advantages in creating an educational Intranet, some of them being:

- ***Cost-Effectiveness***

Intranet tools are inexpensive in initial purchase and deployment. A variety of client and servers-side software is almost free for academic or non-commercial use. The Intranet's platform-independence usually eliminates the need to create different versions of the same application.

- ***Asynchronous Global Information***

Information can be accessed any time and anywhere, thus overcoming the time and space dependent limitations.

- ***Universal Communication***

With proper authorization, an individual on an Intranet can interact with any other individual, and beyond with outside world.

- ***Security***

Protecting information, even within an educational network, is critical. Intranets are protected by a firewall, a network configuration usually created by hardware and software that forms a boundary between networked computers within the firewall from those outside the firewall. For Internet access, Intranets rely on proxy servers, a special server that typically runs in conjunction with a firewall and allows access to the Internet from within the firewall. This enables institutions to make only necessary information available to the outside world (based on means of privileged access, such as username/password-based authentication) thereby avoiding the problems of security breach, server overload and access of illegal information.

Marotta (2006) contributes on this by emphasizing that an Intranet typically has three features lacking on the Internet: *Speed* - broad bandwidth, *Security* - private internal network (LAN/WAN), protected from Internet users by a firewall and *Control* - enterprise network management to ensure reliability.

3.7 RELATED WORKS

1) *"Apply Object-Orientation and UML to the Development of Web-based Learning System"* by Choe Sun Yong and Zhiming Liu is the report showing how object-oriented techniques and UML can be used in modeling and development of a Web-based learning system (Yong et al., 2003). This report was published by UNU/IIST in 2003. UNU/IIST is located in Macau, China. It is one of the Research and Training Centres of the United Nations University, part of the United Nations. It started operations in July 1992. UNU/IIST is jointly funded by the Governor of Macau and the governments of the People's Republic of China and Portugal. The mission of UNU/IIST is to assist developing countries in the application and development of software technology. Yong et al. (2003) in their report, consider how object-oriented techniques and UML through the requirement capture and analysis, design, and implementation can be used in the development of a Web-based learning system. As the starting cycle in the Rational Development Process (RDP) of the whole system, they carried out the requirement analysis and design of the sub-system that is only concerned with Web-based learning in computer science as a case study. The structure of the database obtained was the design class diagram.

Steps of designing a system in this document include:

- Providing goals for the system to be developed
- Stating functions that a system is supposed to do
- Creation of use case and use case diagrams
- Creation of a system conceptual diagram
- Creation of system sequence diagrams and identifying system operations
- Creation of contracts for system operations
- Creation of interactive diagrams (sequence and collaboration)
- Creation of a design class diagram
- Mapping a design to code

2) *"Unified Modeling Language Guide Version 0.2.1 May 13, 2001"* in the URL http://www.comptechdoc.org/independent/uml/begin/ (Basic UML Guide, 2001) is the document which addresses steps involved in the design process of a project. The UML design process as explained in this document involves the creation of various graphical or text based documents. In UML, these documents are called artifacts and they describe the output of a step in the process. The UML design process has two main parts which are:

- Analysis - What is the problem?
- Design - How should the problem be solved?

The reason for this analysis and design process is to allow the project to be broken down into component parts. Artifacts (Documents) created are as shown in table 3.1 (normally in the order shown).

Table 3.1: Artifacts for Analysis and Design Phases

Phase	Artifact (Document)
Analysis Phase	• Use Case Diagram • High Level Use Case Diagram • Expanded Use Case Diagram • System Sequence Diagram • Domain Model (formally called conceptual model) • Operation Contract
Design Phase	• Collaboration Diagram (Also called interaction diagrams) • Design Class Diagrams

Both above documents explain clearly steps on design process using object orientation and UML. Implementation in an object-oriented programming language requires writing source code class definitions and method definition based on design class diagrams. It is basically required to define classes with methods and simple attributes, add reference attributes, and define methods from collaboration diagrams.

In the course of our research, the design class diagrams reached by the two above referred documents are platform independent model (PIM) as applied in MDA. The actual design class diagram to be implemented hereby known as Platform Specific Model (PSM) from MDA will be reached after being transformed as stated earlier. The research is trying to closely relate object oriented system analysis and system design approach and MDA in both cases using UML.

3.8 DISCUSSION

Software design approach is applied simply to produce a software solution to a problem. To produce quality software, we need to thoroughly understand the requirements that satisfy the users' needs. Visualization in the course of continuous improvement is a necessary basis for the participation of the personnel, and allows end-users to grasp the concept of operations of the system without having to understand software terminologies.

A model is used for understanding a system behavior properly before its actual implementation. Integration of the power of models as emphasized by OMG with software development lifecycle stages promotes description of a system from different viewpoints, each focusing on particular concerns. A viewpoint, applied to a system, gives a view of that system. Customization of open source LMS platforms can be used to develop a system which is optionally fitted in the specific context.

The coming chapter discusses the Web technologies in theoretical point of view and gives the practical application of it by designing e-bookstore database.

4.0 WEB BASED TECHNOLOGIES

4.1 INTRODUCTION

Information and Communications Technology (ICT) can be defined in many ways depending on the ICT area of application concerned. Generally, ICT covers any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form. Apart from the above concern of ICT, importantly is also the way these different uses can work with each other.

This chapter gives a theoretical review of Web based technologies. It also shows how theory can easily be understood when "learning by doing" technique is employed through designing a Web based database system. Here online e-bookstore shop was developed for this purpose.

4.2 THEORETICAL REVIEW

The World Wide Web (WWW or Web in short) provides a simple 'point and click' means of exploring the immense volume of pages of information residing on the Internet (Connolly et al., 2005). Information on Web is presented on Web pages, which appear as a collection of text, graphics, pictures, sound and video. In addition, a Web page can contain hyperlinks to other Web pages. Much of the Web's success is due to (Connolly et al., 2005):

- The simplicity with which it allows users to provide, use and refer to information distributed geographically around the world
- Providing users with the ability to browse multimedia documents independently not based on the type/make of the computer hardware being used
- Compatibility with other existing data communication protocols such as File Transfer Protocol (FTP)

Connolly et al. (2005) explain that the Web consists of computers that can act in two roles: as servers for providing information such as Apache server; and as clients, usually referred to as browsers for requesting information such as Internet Explorer (IE).

The theoretical review of the Web base technologies studied include HTML, XHTML, CSS, Java Scripting language and PHP server side scripting language. There are much more in this to be covered like MySQL Database engine, XML and WAMP (Windows, Apache, MySQL and PHP) windows local server.

4.2.1 HTML, XHTML, CSS

Connolly et al. (2005) state that HTML is a system for making up, or tagging a document so that it can be published on the Web. HTML defines what is generally transmitted

between nodes in the network. It is a simple, yet powerful, platform-independent document language. As stated by Shannon (2007) HTML is a computer language devised to allow Web site creation. These Web sites can then be viewed by anyone else connected to the Internet. The definition of HTML is HyperText Markup Language (Shannon, 2007):

- HyperText is the method by which you move around on the Web — by clicking on special text called hyperlinks which bring you to the next page. The fact that it is hyper just means it is not linear — i.e. you can go to any place on the Internet whenever you want by clicking on links
- Markup is what HTML tags do to the text inside them. They mark it as a certain type of text (for example 'italicized text')
- HTML is a Language, as it has code-words and syntax like any other language

HTML was originally developed by Tim Berners-Lee and was standardized in November 1995. The language has evolved and the World Wide Web Consortium (W3C) recommended the use of HTML4.01, which has mechanisms for frames, style sheets, scripting and embedded objects.

W3C defines XHTML as the latest version of HTML 4.01. XHTML will gradually replace HTML. In early 2000, W3C produced XHTML 1.0 as a reformulation of HTML 4 in XML (Connolly et al., 2005). Gowans (2001) says that XHTML stands for Extensible Hypertext Markup Language and is a bridge between HTML and XML. XHTML was created for two main reasons:

- To create a stricter standard for making Web pages, reducing incompatibilities between browsers
- To create a standard that can be used on a variety of different devices without changes

Evjen et al. (2007) reveal that one of the major changes to HTML which was introduced to XHTML is that tags must always be properly formed. With the HTML specification you could be very sloppy in your coding with missing tags and incorrect formation without many problems, but in XHTML this is very important. The biggest change in XHTML is the way in which you write them. Tags and formats must be correct. The main changes to the HTML tags in XHTML are; tags must always be in lower case, they must all be properly formed, properly nested, must have document type and all tags in XHTML must be closed (Gowans, 2001).

CSS stands for Cascading Style Sheets. A style defines how an HTML element is displayed. Style sheet refers to the document itself. Cascade is the special part. A Web style sheet is intended to cascade through a series of style sheets (Kyrnin, 1997). Rotter et al. (2000) tell that HTML allows designers to determine how a document is viewed in a browser over the World Wide Web by applying tags that manipulate the appearance or assign styles to the text. The purpose of cascading style sheets (CSS) is to allow Web authors to manipulate a Web page's appearance without affecting its HTML structure. Style information can be stored in the header of a given HTML page (Internal Style),

within a given tag (Inline style) and in a separate file which is then linked to the HTML page by a reference in the page header (External style) (Kyrnin, 1997).

Nielsen (1997) defines CSS as an elegantly designed extension to the Web and one of the greatest hopes for recapturing the Web's ideal of separation of presentation and content. Kyrnin (1997) notices that CSS is used to style Web pages, but there is more to it than that, CSS are used to style XHTML and XML markup. This means that anywhere you have XML markup (including XHTML) you can use CSS to define how it will look like. CSS is also used to define how Web pages should look like when viewed in other media than a Web browser. For example, you can create a print style sheet that will define how the Web page should be printed out and another style sheet to display the Web page on a projector for a slide show (Kyrnin, 1997).

4.2.2 Web Sites

A Web site is a collection of documents written in the HTML language. When a user looks at a Web site with a browser (e.g. Netscape, Internet Explorer (IE), Mozilla Firefox, etc), the browser is able to follow the instructions presented to it in HTML to make a Web site appear in a certain way. A Web site can either be a static Web site or a dynamic Web site.

- Static Web Site

Connolly et al. (2005) explain that an HTML document stored in a file is an example of a static Web page. The content of the document does not change unless it is changed, that is, if the user were to reload a static Web site, they would see the exact same content every time. Static Web site contents are written directly by an author, and when the user goes through the site, that code is downloaded into a browser and interpreted.

- Dynamic Web Site

In contrast to a static Web site, a dynamic Web site is the one whose content is regenerated every time a user visits or reloads the site. Connolly et al. (2005) comment that a dynamic Web page is generated each time it is accessed. As a database is dynamic, contents are changing as a user creates, inserts, updates and deletes data. Generating dynamic Web pages is much more appropriate approach than creating static ones. This method is gaining popularity as the technology to generate Web pages instantly from a database query. A dynamic Web page is stored on the Web server with no actual data but instead a template for the HTML code and a query. When a client accesses the page, the query is executed, and an HTML page containing the data is generated. There are a variety of languages available to make a dynamic Web site, one of them is PHP: Hypertext Preprocessor (PHP).

4.2.3 Scripting Languages

Scripting languages are becoming increasingly popular on the Web, because they can be used to make Web pages more dynamic and interactive. As described by Connolly et al. (2005), scripting languages: are interpreted directly from the source code and permit scripting within an HTML document, allow the creation of functions embedded within HTML code, may be executed within the browser or at the server before the document is sent to the browser and allow various processes to be automated and objects to be accessed and manipulated. Programs can be written with standard programming logic such as loops, conditional statements and mathematical operations.

There are two types of scripting languages: client-side and server-side (AccessIT, 2002).

- Client-side scripting is scripting that does all of its processing on the users own computer. It is commonly used to create pop-up windows, instant-redirect pulldown menus, shopping-cart calculations, and mouseover effects (i.e., menus or images that change when the user's mouse passes over them). JavaScript is the most popular client-side scripting language.
- In contrast, Server-side scripting performs all of its processing on the Web server and delivers a final product (the Web page) to the user's browser. Server-side scripting does not, in and of itself, present accessibility problems. Like all Web content, however, server-side scripts must produce content that follows principles of accessible design. Server-side scripting language integrates databases into the Web environment. PHP is the most popular server-side scripting language.

The construction for both client-side and server-side scripting languages are the same, except the server side has additional functionality.

i. Java Scripting Language

By definition, JavaScript is a client-side scripting language. This means the Web surfer's browser will be running the script. JavaScript has been around for several years now, in many different flavors. JavaScript was created by Netscape for their Navigator 2.x (late 1995). JavaScript was specifically designed to work together with HTML (and XHTML) to create more dynamic Web pages (Connolly et al., 2005).

JavaScript allows HTML pages to include functions and scripts that can recognize and respond to user events such as mouse click, user input and page navigation. There are many uses for the powerful JavaScript language. Mentioning few things are Mouse Trailers (an animation that follows your mouse when you surf a site), Drop Down Menus, Alert Messages, Popup Windows, HTML Form Data Validation etc.

JavaScript is certainly the most popular scripting language for Web documents, but it isn't the only one. Other scripting languages are AppleScript, Visual Basic Scripting (VBScript), and languages such as UNIX's shell scripting languages. Visual Basic Scripting (VBScript) runs a distant, but occasionally significant, second place in the Web

scripting world, despite the fact that it's a Microsoft-only technology that's only supported in Internet Explorer for Windows. VBScript, Microsoft's Visual Basic Scripting Edition, is a scaled down version of Visual Basic for use with Web pages and other applications that uses Microsoft Active X controls. VBScript is very similar in use and syntax to JavaScript except it is based on a subset of Microsoft's Visual Basic (VB) language. While it doesn't offer the functionality of Visual Basic, it does provide a powerful, easy to learn tool that can be used to add interaction to Web pages (Peters, 2005).

Though, JavaScript and VBScript are both popular scripting languages for Web browser applications, JavaScript will be applied in this thesis due to the following advantages (Peters, 2005; WEB/420 Team C, 2004) over VBScript:

- JavaScript is the default scripting language for browsers but VBScript must be specified as the scripting language
- JavaScript has cross-platform support from all popular browsers while VBScript is supported by Microsoft Internet Explorer only; other browsers may not run the script
- JavaScript is case sensitive but VBScript is not this would not be prone to as many syntax errors
- JavaScript is supported widely on both the server and client sides, but VBScript is for server side only, with only IE for client side

Considering security to JavaScript, care was taken to build some security features into JavaScript. For example client-side JavaScript cannot access network resources or write to file systems. In theory, downloaded scripts are run by default in a restricted 'sandbox' environment that isolates them from the rest of the operating system. Scripts are permitted access only to data in the current document or closely related documents (generally those from the same site as the current document). No access is granted to the local file system, the memory space of other running programs, or the operating system's networking layer (Peters, 2005).

ii. PHP Server Scripting Language

Online Web site (2008) writes that there are four popular scripting languages: PHP, Perl, Active Server Page (ASP) and Java Server Pages (JSP) used to write server side scripts. ASP is for windows programming background. If ASP is used, windows hosting package should be chosen. ASP is primarily a Windows technology, but with limited support on other platforms. Perl is being replaced by PHP and so is not a consideration and JSP is a Java-based system for embedding Java-related code in HTML pages. JSP is the preserve of large corporates and it is not the choice of small/medium Web site designers. PHP is supported on both Microsoft and Linux Web servers and will be applied in this e-LMS system development.

PHP stands for PHP: Hypertext Preprocessor. PHP is a server-side scripting language. Connolly et al. (2005) state that PHP is a popular open source HTML-embedded scripting language, which is supported by many Web servers including Apache hypertext transfer

protocol (HTTP) Server and is the preferred Linux Web scripting language. When you create a static Web page, you simply write HTML code. Writing a dynamic page with PHP is similar, except you embed the PHP code inside HTML code. For this reason, PHP is called an HTML-embedded scripting language. The goal of the language is to allow Web developers to write dynamically-generated pages quickly. One of the advantages of PHP is its extensibility. More advantages of PHP are:

- PHP is available at no cost
- PHP is FREE to download from the official PHP resource: www.php.net
- PHP is a Free Software so you have the Freedom to run, copy, distribute, study, change and improve it
- PHP offers cross-platform compatibility. In other words, it will not matter what platform (Microsoft Windows, or a version of Unix/Linux) users are running, since there is no need for any additional software in order to see PHP's dynamic content. This is because the dynamic content is processed on the server side, and then sent as if it was static
- PHP is compatible with almost all servers used today (Apache, 10IIS, etc.)
- PHP is easy to learn and runs efficiently on the server side

A popular choice nowadays is to use the open source combinations of Apache HTTP Server, PHP, and one of the database systems MySQL. PHP runs on the server side, which means that the Web server that sends an HTML file to a user's browser, will carry out the instructions found in the embedded PHP code first, and then send the output of the PHP code along with the HTML code. The results are the Web pages with dynamic content.

4.2.4 MySQL Database Engine

The database system as it has been explained by Riordan (2005) describes all the components, all the software and the data that goes into making a production system. These components include the application, the database, the database engine and the middleware. MySQL is a database engine at the lowest level. A database engine defines a structure for storing information. In a database, there are tables containing rows, columns, and cells. Databases are useful when storing information categorically.

Russell (2005) mention that there are many features contribute to MySQL's standing as a superb database system. Its speed is one of its most prominent features. In a comparison to several other databases (Oracle, [11]MS SQL, [12]IBM DB2, and Sybase [13]ASE), MySQL and Oracle tied for best performance and for greatest scalability. For a database long dismissed by many people, MySQL is remarkably scalable, and is able to handle tens of thousands of tables and billions of rows of data. Plus, it manages small amounts of data quickly and smoothly.

[10] IIS - Internet Information Server
[11] MS - Microsoft
[12] IBM – International Business Machines
[13] ASE – Adaptive Server Enterprise

Gilmore (2004) also gives a number of features that makes MySQL so popular. High performance is the major concern which is built by very specific optimization of the following features:

- Multiple table handler; MySQL offers three table handlers for managing data. Each of these table handlers, HEAP, InnoDB and MyISAM bears its own strengths and weaknesses.

  Each table has its advantages and disadvantages. As it has been emphasized by Gilmore (2005), InnoDB is a robust transactional table handler. InnoDB offer users a powerful solution for working with very large data stores. It is a complete database back end unto itself.

- Query caching; MySQL enhances the greatest speed by allowing query caching. MySQL will store SELECT queries, along with their corresponding results. As subsequent queries are executed, MySQL will compare them against the cached queries.

- Full-Text Indexing and searching; this feature greatly enhances the performance of mining data from text-based columns. This feature also enables producing results in order of relevance in accordance with how closely the query matches the row.

- Replication; replication allows for a database located within one MySQL server to be duplicated on another, which provides a great number of advantages, e.g. replication greatly increase availability, provides a means of backing up a database.

MySQL comes with quite a few utilities, or clients, each of which provides interfaces for carrying out various tasks pertinent to server administration. *"mysql"* client is an extremely useful SQL shell, capable of managing almost every conceivable aspect of a MySQL server. This includes creating, modifying and deleting tables and databases, setting user access privileges, viewing and modifying the server configuration, and querying table data (Gilmore, 2004).

The *"phpMyAdmin"* being another MySQL client is a Web-based, third-party client program, MySQL administration written in PHP. It is not only very stable, but it offers a number of compiling features (Gilmore, 2004):

- It is a browser-based allowing easy management of remote MySQL databases from anywhere you have access to the Web
- Administrators can exercise complete control over user privileges, passwords and resource usage, as well as create, delete and even copy user accounts

4.2.5 Extensible Markup Language (XML)

XML stands for Extensible Markup Language. XML is a markup language very similar and related to HTML, but HTML is used to mark up text for presentation purposes where

as XML is used to mark up text for data representation purposes (Evjen et al., 2007). XML was designed to describe data. XML tags are not pre-defined you must define your own tags. XML uses a Document Type Definition (DTD) or an XML Schema to describe the data. XML with a DTD or XML Schema is designed to be self-descriptive. XML is a W3C Recommendation. Connolly et al. (2005) define an XML to be a meta-language (a language for describing other languages) that enables designers to create their own customized tags to provide functionality not available with HTML.

Evjen et al. (2007) explain that XML has distinct advantages, thus making it as popular as it is today. These advantages are:

- XML is easy to read and understand
- A large number of platforms support XML and are able to manage it through an even larger set of tools available for XML data reading, writing and manipulation
- XML can be used across open standards that are available today
- XML allows developers to create their own data definitions and models of representation
- XML is simpler to use than binary formats when you want to represent complex data structures

4.2.6 Windows, Apache, MySQL, PHP (WAMP)

WAMP is an acronym for Windows, Apache, MySQL and one or more of Perl, PHP and Python. It was modeled after the more well-known LAMP, referring to the all-open source/free software approach which uses Linux instead of Windows. Each element of the WAMP acronym provides an essential layer of functionality:

- Microsoft Windows is the operating system
- Apache is the Web server
- MySQL is the DBMS (database management system or database server)
- PHP is an object-oriented Web scripting language
- Perl is a powerful, general-purpose, object-oriented scripting language
- Python is yet another powerful, general-purpose, object-oriented scripting language

4.2.7 Database Security

As the use of the Web grows on both Intranets and the public Internet, information security is becoming crucial. The Web provides a convenient, cheap, and instantaneous way of publishing data. With many systems implementing dynamic creation of Web pages from a database, corporate information security is even more vital, since anyone with a Web browser can view data in a database that is not properly protected. For Web security, there are three primary areas to address (Rahmel, 1997):

- ***Server security*** -- ensuring security relating to the actual data or private HTML files stored on the server. It involves limiting access to data stored on the server. The

process of publishing data to the Web often requires information systems specialists implementing the security policy.

- ***User-authentication security*** -- ensuring login security that prevents unauthorized access to information. Authentication security governs the barrier that must be passed before the user can access particular information. The user must have some valid form of identification before access is granted. Logins are accomplished in two standard ways: using an HTML form or using an HTTP security request. This method has the advantage of letting the Database Administrator (DBA) define a particular user's privilege. By using a table created by the DBA, numerous security privileges specific to a particular project can be defined.

- ***Session security*** -- ensuring that data is not intercepted as it is broadcasted over the Internet or Intranet. After the user has supplied proper identification and access is granted to data, session security ensures that private data is not intercepted or interfered with during the session. It involves encrypting all of the information that flows both ways.

4.2.7.1. Computer-Based Security Controls

Data is a valuable resource that must be strictly controlled and managed. The term security refers to the protection of the database against unauthorized access, either intentional or accidental. Database security is concerned with avoiding: theft and frauds, loss of confidentiality (secrecy), loss of privacy, loss of integrity and loss of availability. Security considerations apply not only to the data held in database, but also to hardware, software and people. Connolly (2005) clearly says that the type of countermeasure to threats on computer systems range from physical controls to administrative procedures. He continues by describing computer-based security controls for a multi-user environment to be:

- **Authorization**

Authorization means the granting of a right or privilege that enables a subject to have legitimate access to a system or a system's object. The process of authorization involves authentication (that is mechanism that determines whether a user is who he or she claims to be) of subjects requesting access to objects, where 'subject' represents a user or program and 'object' represents a database table. A system administrator is usually responsible for allowing users to have access to a computer system by creating individual user account (unique identification and a password). This is done along with giving a user the right to use the DBMS.

- **Access Control**

The typical way to provide access control for a database system is based on the granting and revoking of privileges. A privilege allows a user to create or access (that is read, write or modify) some database objects (such as relation, view or index) or to run certain

DBMS utilities. Privileges are granted to users to accomplish the tasks required for their jobs.

- **Views**

A view is the dynamic result of one or more relational operations operating on the base relations to produce another relation. A view is a virtual relation that does not actually exist in the database, but is produced upon request by a particular user, at the time of request. The view mechanism provides a powerful and flexible security mechanism by hiding parts of the database from certain users. The user is not aware of the existence of any attributes or rows that are missing from the view. A view can be defined over several relations with the user be granted the appropriate privilege to use it, but not to use the base relations. In this way, using a view is more restrictive than simply having certain privileges granted to a user on the base relation(s).

- **Backups and Recovery**

Backup is a process of periodically taking a copy of the database and log file (and possibly programs) on to offline storage media. A DBMS should provide backup facilities to assist with the recovery of a database following failures. A DBMS should provide logging facilities, sometimes referred to as journaling, which keeps track of the current state of transactions and database changes, to provide support for recovery procedures.

- **Integrity**

Integrity constraints ensure that the data is accurate. For example, relational integrity constraints are: entity integrity (in a base relation, no attribute of a primary key can be null), referential integrity (If a foreign key exists in a relation, either the foreign key value must match a candidate key value of some tipple in its home relation or the foreign key value must be wholly null). Integrity constrain also contributes to maintaining a secure database system by preventing data from becoming invalid, and hence giving misleading or incorrect results.

- **Encryption**

This is the encoding of the data by a special algorithm that renders the data unreadable by any program without the decryption key. Some DBMS provide an encryption facility for this purpose.

- **Redundant Array of Independent Disks (RAID)**

The hardware that the DBMS is running on must be *fault-tolerant*, meaning that the DBMS should continue to operate even if one of the hardware components fails. This suggests having redundant components that can be seamlessly integrated into the working system whenever there is one or more component failure. The main hardware components that should be fault-tolerant include disk drives, disk controllers, central processing unit (CPU), power supplies and cooling fans.

4.2.7.2. DBMS and Web Security

Internet communication protocol relies on TCP/IP as the underlying protocol. However TCP/IP and HTTP were not designed with security in mind. With a three-tier architecture that is popular in a Web environment, we have the complexity of ensuring secure access to, and from, the database. The security of such architecture requires different products and mechanisms (Connolly, 2005). Some of the issues associated with database security in Web environment are:

- **Proxy Servers**

A proxy server is a computer that sits between a Web browser and a Web server. The two main purposes of a proxy server are to improve performance and filter requests. A proxy server saves the results of all the requests for a certain amount of time. It can significantly improve performance by simply returning the requested Web page from the cached page that it had already fetched. A proxy server can also be set to prevent users from accessing a specific set of Web sites.

- **Firewalls**

A firewall is a system designed to prevent unauthorized access to or from a private network.

4.3 WEB BASED TECHNOLOGIES ON ONLINE e-BOOKSTORE SYSTEM DESIGN

The goal of this exercise was to create the base for understanding Web based technology in a practical perspective way. The motive to this is that the e-LMS to be developed will be a Web based system and it will need the application of this knowledge. The exercise was to develop an e-commerce site for a bookstore with PHP, MySQL, XHTML, CSS, JavaScript and Apache as the Web server. In this exercise, the concentration was on how to display and show information about books. Concerning the database, it was given that; every book should belong to a category such as science fiction, thriller and/or history. The data about each book should be at least International Standard Book Number (ISBN), title, publisher and author. Additional data could be the URL to the publisher, picture and perhaps reviews.

Concerning the interface, it was suggested to have a look at existing Web based book stores such as Amazon (http://www.amazon.com/), Barnes & Nobles (http://www.barnesandnoble.com/) etc and use them as inspirations. Online book store was designed using Windows, Apache, MySQL and PHP (WAMP) local server.

4.3.1 Main Objective

The main objective of this design exercise was to get the touch of designing Web-Based platforms and to learn basics in designing Web-based databases. Along side with this,

was to learn useful technologies applied in Web based platforms in a practical aspect view. These technologies include Hypertext Markup Language (HTML), Extensible Hypertext Markup Language (XHTML), XHTML Document Type Definition (DTD), Cascading Style Sheets (CSS), a Web side JavaScript Language, server side PHP: Hypertext Preprocessor (PHP) scripting language, here PHP 5 was studied, MySQL Database Server and Apache application server. All these knowledge are useful in developing an interactive e-Learning Management System (e-LMS) for Tanzanian secondary schools to be done in my PhD research.

4.3.2 Material Requirements

To be able to do online bookstore, the followings were needed; the theoretical and practical knowledge of the technologies mentioned in section 4.2 above; Linux, the operating system; Apache, the Web server; MySQL, the database management system (DBMS) or database server; PHP scripting language and a personal computer having windows 2000 operating system or above. For convenience, WAMP for Microsoft windows was used. WAMP is an open source package for windows combining Apache, MySQL and one or more of Perl, PHP and Python. It is a form of mini-server that can run on almost any Windows Operating System.

Together with reference books on PHP, MySQL and other Web technologies, the theoretical and practical knowledge of the technologies I wanted was also obtained from the URL http://www.w3school.com.

4.3.3 e-Bookstore System Requirement and Analysis

The design started by identifying users/stakeholders to be involved in the e-bookstore system and their action boundaries towards the use of the system. The following minimum numbers of users were identified and summarized in use case diagram, figure 4.1:

- ***System Administrator;*** is the one who will be responsible in administering the system as a whole. He will be responsible in :
  - Uploading important information about the book. These information include: book title, author name/s, publisher name, ISBN etc
  - Creating and editing functional components of the system e.g. user interface pages
  - Manage users and their event log-in
  - Publishing selected important book information to the public
  - Maintain the system
- ***Customer/visitor;*** represents any person who visits the e-bookstore home page and wants to view any information about books. This person can also be the one who will be interested in purchasing/ordering books from the bookstore. A visitor can be registered as a customer upon submission of needed information. The system will provide the following privileges to the customer/visitor:

- Be able to view important information about the book provided to the public as a visitor
- Be able to perform self registration as a customer after providing needed information
- Be able to request for extra information about purchasing/ordering books
- Be able to purchase/order books online after meeting provided requirements for purchasing/ordering books

➢ ***Reviewer;*** represents the one who will be interested to give views on the book s/he read. The system will provide the following privileges to the reviewer:

- Be able to perform self registration as a reviewer after providing needed information
- Be able to write reviews on a certain book and send to the system
- Be able to receive responds about the review sent
- Be able to view important information about the book provided to the public

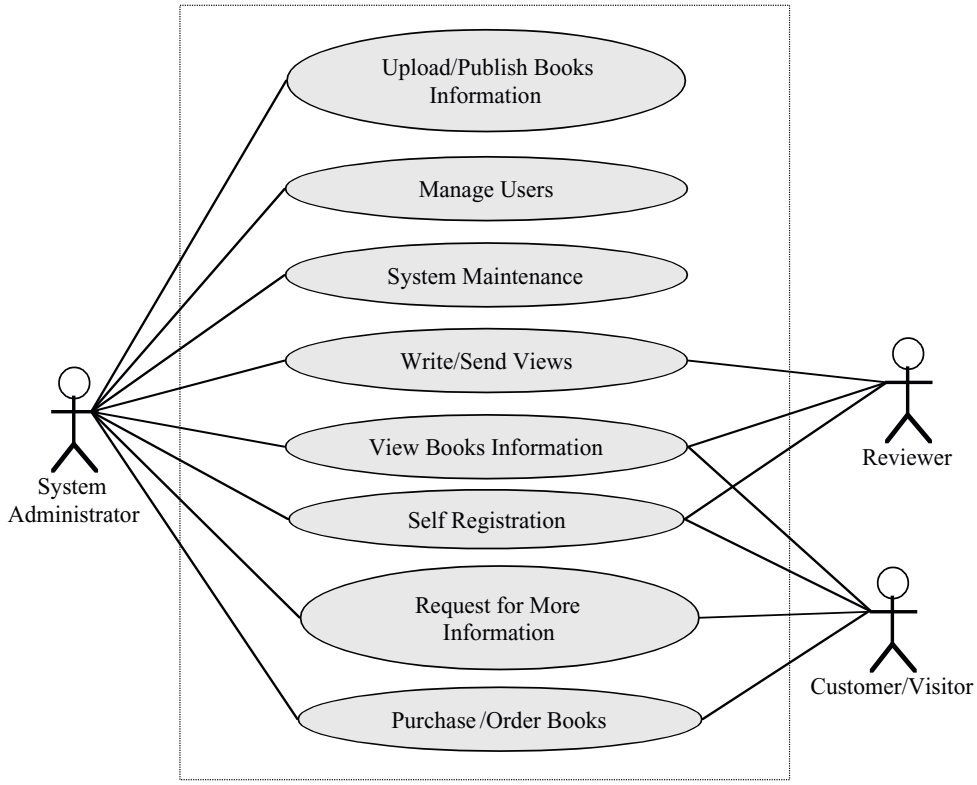

Fig. 4.1: e-Bookstore Use Case Diagram

4.3.4 e-Bookstore System Architecture

Online bookstores are intended to be viewed and used by many people world wide. In this case the technique of designing a three-tier architecture for Web based systems was

employed. Three-tier architecture organizes a distributed client-server systems in a flexible manner.

Using a WAMP installed into a personal computer window, it was easy to get the needed software for the system all together. MySQL database server that stores data, the apache application server that controls the communication (basic system functionalities) and PHP which comes together in a single package i.e. WAMP. This means that the server was viewed as a local host within the same computer. Figure 4.2 shows the e-bookstore architecture within the computer windows. All three components for a three-tier architecture were implemented. These components are:

- The client component was used to provide the user interface for the Web-based application. It is a front-end layer. Using a standard Web browser of the computer, which support XHTML, JavaScript, and CSS Web technologies, the user will access database through the Web server. The access to the local server was made possible through using created user interface Web pages. In this case the same personal computer was used as a client.

- The application server (Apache) is responsible for interacting with the client and the database server (MySQL). It receives and processes the data from the client requests, retrieves information (data) from database if needed; it also generates a client response and stores the necessary data into database. Apache Web server running in windows operating system and a server side script language to be used is PHP are all included in WAMP package. They will both be used to connect to the back-end (MySQL database).

- The database server (MySQL) is the place where data are being stored. The database server maintains the data needed for the Web application. It is a back-end layer. It stores data and controls the basic system functionality. MySQL database server is also included in WAMP installed in computer windows.

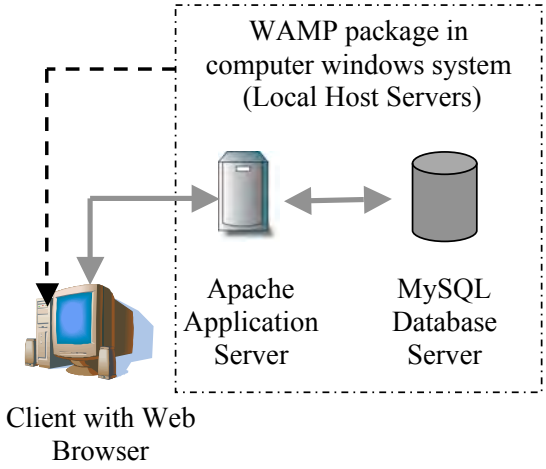

Fig. 4.2: e-Bookstore Architecture

4.3.5 Database Structure, Tables and ERD

Table creation started by thinking on important information which is being used to identify a book. The minimum information considered to identify a book with reference to the time limit of two months to develop e-bookstore was as follows:

- *Title* to represent the title of the book
- *Author* to represent the information of the author/s
- *ISBN* to represent the unique identification of a book
- *Publisher* to represent the information about the publisher
- *Publisher URL* to represents the URL of the publisher
- *Category* to represent the subject under which the book falls into
- *Reviews* to represent reviews for the book given by the reviewer
- *Book page numbers* to represent how many pages the book has
- *Book price* to represent the price of the book
- *Book description* to represent the abstract of the book

Considering normalization, which is the process of removing redundancy data from tables and improving storage efficiency, data integrity and scalability, the following tables were created:

- *"Book"* table
- *"Publisher"* table
- *"Category"* table
- *"Author"* table
- *"Review"* table
- *"Customer"* table
- *"Sales*" table as an intermediate table to link "*book*" and "*customer*" tables

Attributes for each table was identified followed by the identification of primary keys and foreign keys to make one-to-many relationship. Foreign keys are columns in a table that refers to primary keys from another table. This serves the purpose of defining data relationships. Table 4.1 shows "*book*" table with attributes as one example of the tables created.

Table 4.1: Book Table and Attributes

**isbn	title	*authorid	*publisherid	*categoryid	price	currency	*reviewerid	publishyear	toc

** Primary key for book table * Foreign keys from corresponding tables

4.3.6 Database and Tables Creation in WAMP

Next step was to create database and tables in MySQL database engine. Database and tables were created by the help of a *"mysql"* command-line client as a powerful means for working with the server, and also by the help of a phpMyAdmin client, a third-party

client program. The database created was named "*bookstore*" and the command used in command-line is:

mysql> create database bookstore;

With "*bookstore*" database the above mentioned tables of type InnoDB were created within the "*bookstore*" database with the help of a command-line. Taking a "*book*" table as one example, below is a code for creating "*book*" table:

```
mysql    >CREATE TABLE book (
         > isbn CHAR (18) NOT NULL,
         > title CHAR (50) NOT NULL,
         >authorname CHAR (120) NOT NULL,
         > publishername CHAR (40) NOT NULL,
         > categoryname CHAR (200) NOT NULL,
         > price DECIMAL NOT NULL,
         > currency CHAR (5) NOT NULL,
         > revieweremail CHAR (30) NOT NULL,
         > publishyear YEAR (4) NOT NULL,
         > toc TEXT,
         > PRIMARY KEY (isbn),
         > INDEX (authorname),
           FOREIN KEY (authorname) REFERENCES author (authorname) ON
           UPDATE  CASCADE ON DELETE RESTRICT,
         > INDEX (publishername),
           FOREIGN KEY (publishername) REFERENCES publisher (publishername)
           ON UPDATE CASCADE ON DELETE RESTRICT,
         > INDEX (categoryname),
           FOREIGN KEY (categoryname) REFERENCES category (categoryname)
            ON  UPDATE CASCADE ON DELETE RESTRICT,
         > INDEX (revieweremai),
           FOREIGN KEY (revieweremai) REFERENCES reviewer (revieweremai) ON
           UPDATE CASCADE ON DELETE RESTRICT);
```

4.3.7 Data Entry Forms

After all tables had been created in a bookstore database, the next step was to develop data entry forms which helped to facilitate data entry into created tables. The following data entry forms were created based on who is going to use these forms:

- **Administrator;** Administrator is the one who is responsible in entering all book information required. The following forms were created:
  - Administrator registration form: this form is used to register a person who takes responsibilities as an administrator, the overall controller of a database
  - Administrator login form: to allow the assigned administrator to login and have a permission to access the database
  - Author data entry form: used by an administrator to enter information about the author of the book

- Book category data entry form: used to enter category of the book
- Book description entry form: used to enter description of the book
- Publisher data entry form: used to enter information about the book publisher
- Sales data entry form; used to enter information about selling, ordering and purchasing books

➢ **Customer:** the one who is interested in ordering and purchasing books:
- Customer registration form: allows a new customer to perform online registration so that he/she can be recognized by the company as a customer
- Customer login form: allows a registered customer to view relevant information provided to customers, order and/or purchase books

➢ **Reviewer:** the one who provide reviews concerning books/s of his/her interest
- Book review data entry form: to be used by a reviewer

A registered customer is provided with a customer home page (customer site). This page gives a customer more privileges to access more information, for example answers to requested information from the administrator. A customer in a customer site can: send e-mail, edit personal information, order or purchase books and get other privileges provided to all visitors.

When administrator logs in, he/she will be forwarded to a page special for administration (administrator Site). In this page, administrator will be provided with a number of links to different data entry forms for different tables. He/she will also be able to view information about books as shown in figure 4.3.

4.3.8 Data Queries

A number of queries, as shown below, were created to view different selected information about books. These displays are also displayed in the bookstore home page to be viewed by all visitors of the page as shown in figure 4.4.
- Display a list of all books present in book shop
- Display a list of all books present in book shop category wise
- Display a list of all books present in book shop by author
- Display a list of all books present in book shop category wise but in tabular form
- Display a list of book authors
- Display relevant book information
- Display relevant book information in tabular form
- Display customer list
- Display book reviews

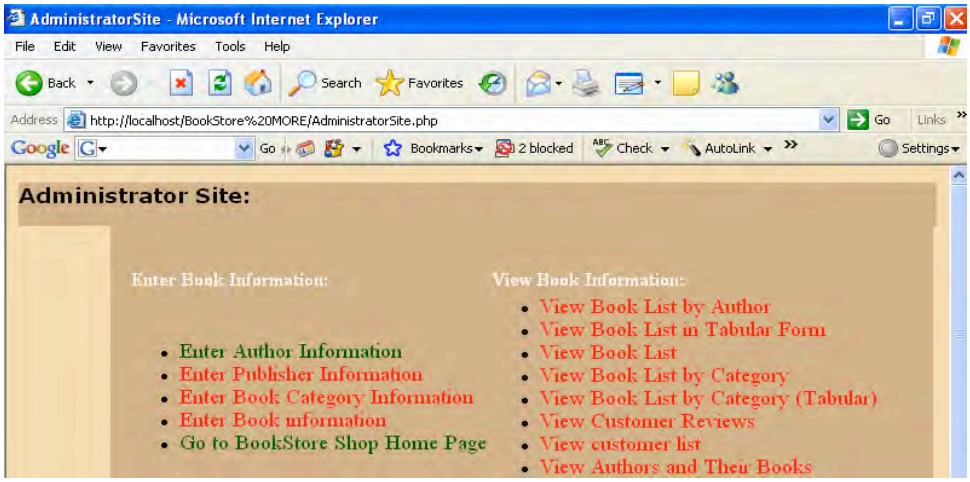

Fig. 4.3: Administrator Site

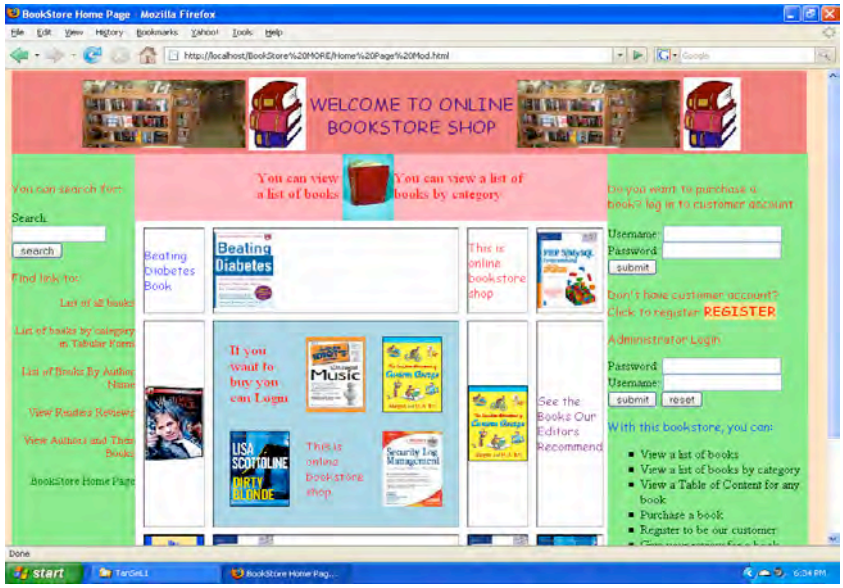

Fig. 4.4: E-Bookstore Home Page

Below is a sample code written to display book information from the database in tabular form. HTML-Kit editor was used to write these codes. The code connects to the database engine (MySQL), selects the database to deal with (bookstore), selects needed table fields from tables and displays what found in these table fields.

```
<?php
   $linkID = @mysql_connect("localhost" , "root" , "root")
         or die("Can't connect to database server!!");
  @mysql_select_db("bookstore") or die("Can't connect to database server!!");
```

```
    $query2 = "SELECT isbn, title, authorname, publishername FROM book";
    echo"<p style=\"color: green; margin-top: 1cm; font-size: 120%; font-eight:bold;\">List
                    of Books in Tabular Form:</p>";
    $result2 = mysql_query($query2) or die(mysql_error());
    echo "<table border='1'>";
    echo "<tr style=\"background-color: OldLace \"> <th>ISBN</th> <th>TITLE</th>
                    <th>Author Name</th> <th>Publisher Name</th> </tr>";
    // keeps getting the next row until there are no more to get
    while($row = mysql_fetch_array( $result2 ))
    { // Print out the contents of each row into a table
        echo "<tr><td>";
        echo $row['isbn'];
        echo "</td><td>";
        echo $row['title'];
        echo "</td><td>";
        echo $row['authorname'];
        echo "</td><td>";
        echo $row['publishername'];
        echo "</td></tr>";
    }
    echo "</table>";
    echo"<br />";
?>
```

4.4 DISCUSSION

The knowledge of database systems, Web technologies and Web based database systems as a whole was the new area to my carrier. Database systems involve a real application of programming. When you enter a new programming area you are faced with a real challenge. My research work involves development of a Web based learning management system. In order to proceed well with my research it was wiser to start with a simple application of Web based technologies. The easiest way to learn new area, especially programming, is by employing "learn by doing" technique, that is, you learn to do by doing. Nellen et al. (2000) emphasize this by saying that if knowledge is power, then we gain that knowledge by doing.

I am personally realizing the power of "knowledge by doing" after starting developing e-LMS for Tanzania secondary schools. I have noticed that the knowledge gained when developing e-bookstore shop is the base for:

- Understanding and easy follow-up of open source codes for open source e-learning platform during customization
- Creating codes for e-LMS
- Modifying open source codes to suite our requirements

The coming chapter gives the system requirement and specifications for the e-LMS to be developed.

5.0 THE e-LMS SYSTEM REQUIREMENT AND SPECIFICATIONS

5.1 INTRODUCTION

Learning materials can be delivered to learners in many ways including the use of learning management systems, the use of compact disk read only memory (CD-ROMs) and even face-to-face delivery (this is hybrid or blended e-learning) (Lating, 2006). Learning design has the potential to develop e-learning by capturing the process of education, rather than simply content (learning materials). This is done by using learning management system, thus LMS is among the selected way to be used in learning material delivery and it is the one addressed in this research. Learning Management Systems play a central role in the Web-based e-learning scenario (Watson et al., 2004). It connects learning contents and learners together in a standardized manner. It manages users, content learning materials and learning events. It manages and administers learning progress and keep track on learning performance. It manages and administers administrative tasks too.

Development of e-LMS use object oriented system analysis and design (OOSA&D) approach along with the power of modeling as applied in Model Driven Architecture (MDA). System requirement and specification phase from system development life cycle (SDLC) in OOSA & D is related to Computation Independent Model (CIM) of the MDA. Modeling will make use of UML language. The main advantage of UML is that different modeling notations can be used at different stages of system development life cycle (SDLC) to represent the system at a proper level of abstraction and to describe both the static structure and dynamic behavior of the system. During requirement specification, UML will capture the requirements of the users of the system and will create the system functions and describe sequence of interactions between actors (users) and the system using a use-case model.

Larman 2004 argues that system requirement is the process whereby users' needs in a software project are identified, modeled and validated. Requirement Specification is concerned with capturing and analyzing the requirements of the client to a system (Yong et al., 2003). System requirement is the most important aspect of building an information system because it is at this moment where what is to be built is being decided. System requirement is an iterative process by which the needs and requirements of individuals and groups significant to the development are researched and identified. When combined with the system analysis stage, the major information for design of a new system can be addressed and documented. This stage describes the system objectives, the work and its constraints to which designers have to comply. The emphasis is on finding and describing the objects or concepts in the problem domain (Larman, 2004). With this regard, this chapter is presenting the followings:

- Identified system requirements
- The e-LMS system architecture components
- The e-LMS system functions
- Stake holders and their privileges in using e-LMS

- Technology and standards, and
- The e-LMS system architecture

5.2 IDENTIFIED SYSTEM REQUIREMENTS

The aim of the first survey presented as part "A" in chapter two (2) was to study the level of e-readiness for project implementation. The findings show that there is a positive movement towards the use of ICT in e-learning in the following areas[14]:

- At National level, one of the objectives of the National ICT Policy of Tanzania is to use ICT to improve the quality of delivery of education and training in all areas including distance learning
- The concerned Ministry, MoEVT has formulated "ICT policy for basic education" to guide the integration of ICT in basic education including Tanzanian secondary school education
- There are a good number of licensed data communication providers in the country namely; TTCL, Wilken Afsat, Datel Tanzania, Equant Tanzania, Simbanet Tanzania, Soft Tech Tanzania and Fastcom Africa. TTCL being the Government affiliated integrated telecommunication company
- Many of the secondary schools surveyed have at least basic requirements including a school computer laboratory, computers, a school library; electricity, telephone and security for the safekeeping of expensive computer systems
- Some of the on-going ICT projects in Tanzania will accelerate easy implementation of e-learning for secondary schools' project. One being the "ICT Implementation in Teachers' Colleges" (http://www.teachers.or.tz). The project is sponsored by Sida and is aiming to improve the quality of pre-service and in-service teacher education by using ICT. MoEVT has also introduced a secondary school syllabus for computer studies

The aim of the second survey was to find, identify and substantiate problems facing Tanzanian secondary schools. Solutions on how to overcome identified problems lead to having system requirements for e-LMS to be developed (as stated in part "B" of chapter 2). Leffingwell et al. (2003) insist on starting with problem analysis during system requirement phase. They define problem analysis to be the process of understanding real-world problems and user's needs and proposing solutions to meet those needs. Leffingwell et al. (2003) key points are:

- The goal of the problem analysis is to gain a better understanding of the problem being solved, before development begins
- To identify the root cause, or the problem behind the problem, ask the people directly involved
- Identifying the actors on the system is a key step in problem analysis

[14] Findings mentioned towards the use of ICT in e-Learning are all clearly discussed in Part A of chapter 2 (ICT Application Status in Tanzania by 2004".

Findings from the second survey show the followings two issues to be the mostly needed by majority of e-learning stakeholders (as stated in part "B" of chapter 2):

- The need to have more self learning materials especially in science and mathematics subjects
- The need to have a good number of self test questions and past paper examination questions for practice

Identified requirements for e-LMS are the primary source of data towards the development of the system. Requirements for developing e-LMS have also taken the approach based on the requirements of the LMS system on broader fundamentals, that is, secondary source of data.

5.3 THE e-LMS SYSTEM ARCHITECTURE COMPONENTS

The e-LMS system architecture is based on the main four components: user component, learning material, assessment activities and communication resources. *User component* is concerned with the main users with different roles to participate in the system. *Learning materials* component is concerned with all areas used in delivering a subject. These are subject notes which include subject syllabus and examples. Subject notes are composed of chapters and topics. *Assessment activities* involve all aspects dealing with evaluating or assessing the learners' understanding of the provided learning materials. Assessment activities contains subject self test questions, chapter exercises and topic exercises. *Communication resources* involve all components in creating collaboration among users in the system. Figure 5.1 shows e-LMS architecture components.

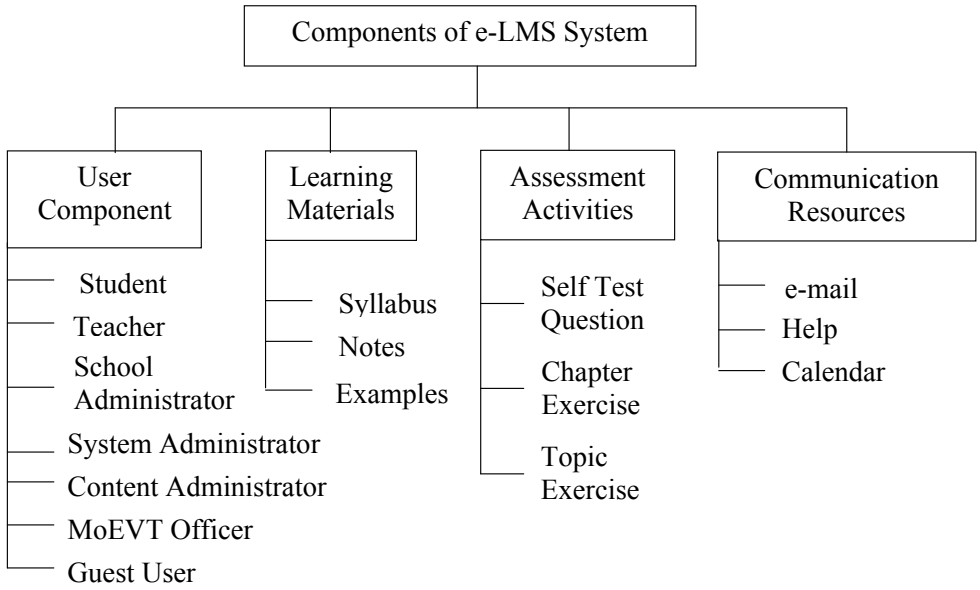

Fig. 5.1: e-LMS System Architecture Components

5.4 THE e-LMS SYSTEM FUNCTIONS

System functions are what a system is supposed to do (Liu, 2001; Yong et al., 2003). In other words, system functions are a list of the specific capabilities a system should be able to do. The system's functions are categorized into two groups (Liu, 2001; Yong et al., 2003):

- Evident functions: are functions that are performed by the system and user are able to tell if they are performed
- Hidden functions: are functions that are performed by the system but user need not be able to tell that they are performed

Like any other learning management system, the e-LMS is aimed at managing learning activities. Referring to some of the system functions noted by Yong et al. (2003), the following as shown in table 5.1 are the basic functions for the e-LMS:

Table 5.1: The e-LMS System Functions

Fn. No.	Function Description	Status
F 1	Define different roles and assign privileges	Evident
F 2	Allow registration and particulars updates of users to the system	Evident
F 3	Record the detailed information of a registered user to the system	Hidden
F 4	Allow registration of subjects to the system, creation and updates of subject chapter, chapter topics and assessment activities	Evident
F 5	Record the detailed information of a registered subject to the system	Hidden
F 6	Allow registration of a user to a subject	Evident
F 7	Record the detailed information of a registered user to a subject to the system	Hidden
F 8	Validate logins information (username and password) entered by the user in order to use the system and allow the registered user to login/out to the system	Hidden
F 9	Display the home page of the role	Evident
F 10	Display available resources for the role	Evident
F 11	Find a subject and display links of a list of all chapters, past papers and a link to syllabus for a selected subject	Evident
F 12	Track student's interaction with the subject	Hidden
F 13	Display syllabus for the subject	Evident
F 14	Find a subject chapter and display links of a list of all topics, extra chapter exercises and a link to topic exercises for a selected subject chapter	Evident
F 15	Track student's interaction with the subject chapter	Hidden
F 16	Find a chapter topic and display learning materials (notes, examples) for a selected subject chapter topic	Evident
F 17	Find and display information resources for Assessment activities (Past papers, chapter exercises, topic exercises and self test exercises)	Evident
F 18	Track user login and logout information to/from the system	Hidden

F 19	Update information record for user login and logout	Hidden
F 20	Display information record for user login and logout	Evident
F 21	Track student's interaction with learning materials	Hidden
F 22	Update information record for student's interaction with learning materials	Hidden
F 23	Display information record for student's interaction with learning materials	Evident
F 24	Track student's interaction with assessment activities	Hidden
F 25	Update information record for student's interaction with assessment activities	Hidden
F 26	Display information record for student's interaction with assessment activities	Evident
F 27	Display relevant information needed for a guest user, e.g. available subjects, subject objectives, and/or subject table of content	Evident
F 28	Display help for system functionality	Evident
F 29	Display calendar	Evident
F 30	Display list of system users	Evident
F 31	Display list of system subjects	Evident
F 32	Handle massage transfer between users through internal mail facility	Hidden
F 33	Handle system database backups	Hidden
F 34	Handle system database restoration/recovery	Hidden
F 35	Handle system database mirroring	Hidden
F 36	Handle system database replication	Hidden

5.5 STAKE-HOLDERS AND THEIR PRIVILEGES IN USING e-LMS

The focus of the e-LMS is placed on providing teachers and students with the necessary IT tools for accessing the educational material and communicating with each other. The e-LMS is considering more users rather than only teachers and students. In each role, use case model is shown to summarize the external interactions between use cases and actors. As summarized in figure 5.2, every user of the system will be able to perform the following basic functions:

- Login into the system
- Logout of the system
- Change password
- Call help on system functionality
- Access provided calendar
- View self login report
- Send e-mail to other users

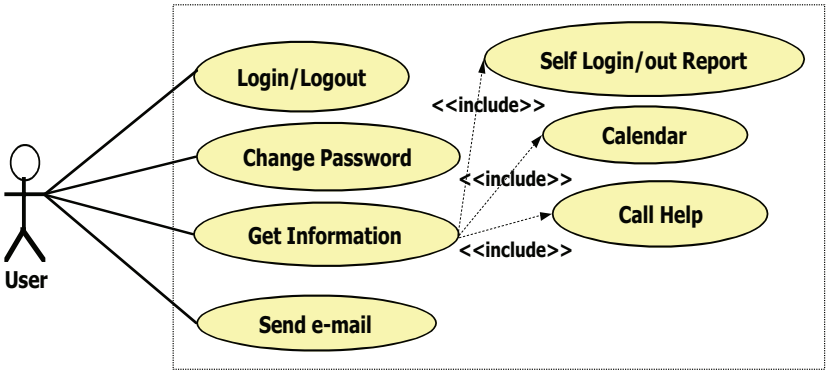

Fig. 5.2: Use Case Diagram for All User Roles

5.5.1 Student

Represents a role of a person who uses learning resources to gain knowledge or skills. The e-LMS is intended to provide students with learning materials and make them communicate with other users (student or teacher) by e-mail. Each student may participate in more than one registered subject and can access the subject materials.

Adopting the categorization of students from Nykänen et al. (1997), students are categorized into two groups: privately registered student and school registered student. Figure 5.3 shows categories of students in e-LMS.

- *Private registered student* is a private student registered to a system privately and not via any school. The registration for private students will be performed by the system administrator. Private student will have the rights to participate in all privileges provided for the student. The learning progress will be recorded for this group of students. To easily identify a privately registered student, private students will be provided with the unique identification.

- *School registered student* is a student registered to a system through school enrollment. The registration for school registered students will be performed by the school administrator. School registered student will have all the rights to participate in all privileges provided for the student. The learning progress will be recorded for this group of students. To identify a school registered student, login information will include providing unique identification for the concerned school.

As summarized in figure 5.4, a registered student will perform the following specific functions in the system:

- View and/or download learning materials
- View and/or download assessment questions
- Provide answers to self test questions
- View self test performance report

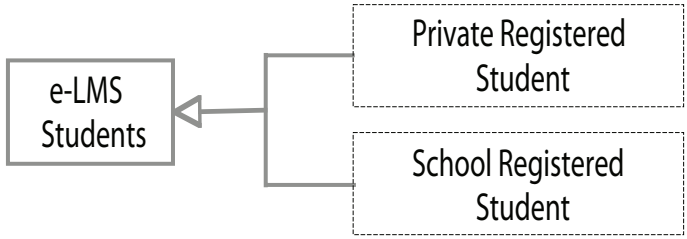

Fig. 5.3: The e-LMS Student Categories

5.5.2 Teacher

Teachers are registered to use the e-LMS by the school administrator. Some competent teachers will provide learning materials as per their area of specialization. Then these learning materials will be uploaded into the learning material repository centrally by the content administrator. In this view, teachers will make use of the system just like students to access learning materials, though they will be having extra privileges like accessing reference answers if available to the given chapter and topic exercises. Teachers will support their school students during the learning process. A teacher will perform the following specific functions in the system, and summarized in figure 5.4:

- View and/or download learning materials
- View and/or download assessment questions
- View and/or download reference answers for all exercises
- View students' log-in history of his/her school
- View student's interaction with learning materials history of his/her school
- View student's interaction with assessment activities history of his/her school

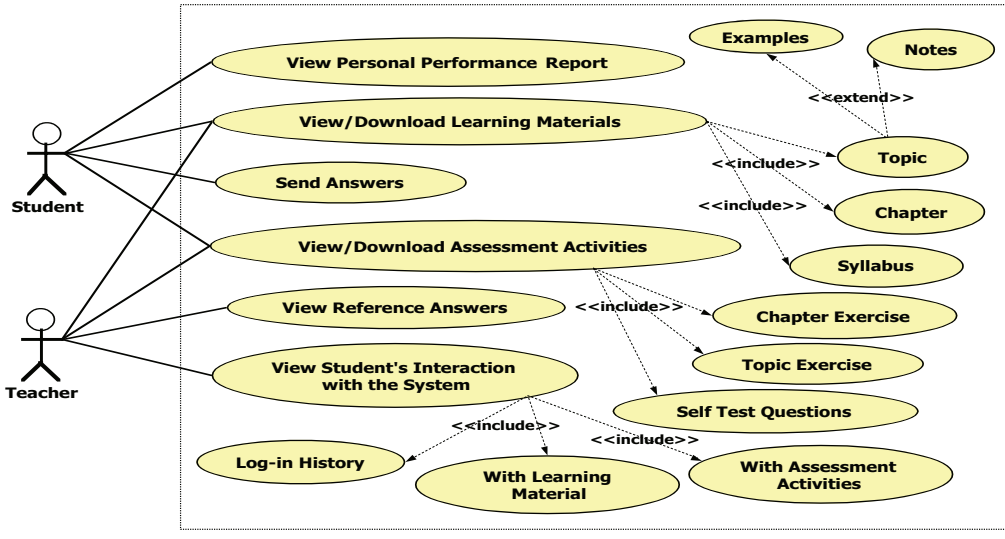

Fig. 5.4: Use Case Diagram for Student and Teacher Roles

5.5.3 School Administrator

The school will be registered to the system and identified by the school unique number (like registration number). A school administrator is responsible in managing students and teachers of his/her school to the system. Any user registered through a school will be identified by a hidden school unique number after providing personal login information. As summarized in figure 5.5, a school administrator will perform the following specific functions in the system:

- Register students of the school to the system
- Register teachers of the school to the system
- Update student's personal particulars of his/her school
- Update teacher's personal particulars of his/her school
- View user logins history of his/her school
- View student's interaction with learning materials history of his/her school
- View student's interaction with assessment activities history of his/her school
- View teacher's interaction with learning materials history of his/her school
- View teacher's interaction with assessment activities history of his/her school

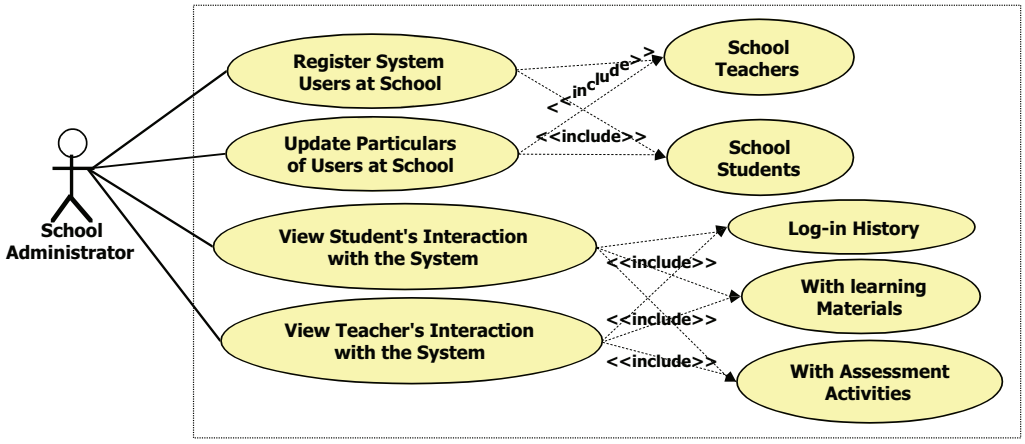

Fig. 5.5: Use Case Diagram for School Administrator Role

5.5.4 System Administrator

System administrator is the overall in-charge of the e-LMS. System administrator needs complete access to the e-LMS database and monitor the use of it. He/she manages system resources like user accounts and assigns privileges. A system administrator adds new system functions and improves the existing ones. A system administrator will perform the following specific functions in the system. Figure 5.6 shows the summary of these functions:

- Register schools and users of the system
- View and/or update school and user personal information
- Delete users of the system
- Get list of all users
- Get list of all subjects
- View system user's logins history
- View student's interaction with learning materials history
- View student's interaction with assessment activities history
- View teacher's interaction with learning materials history
- View teacher's interaction with assessment activities history
- Maintain system functionality
- Update system functionality

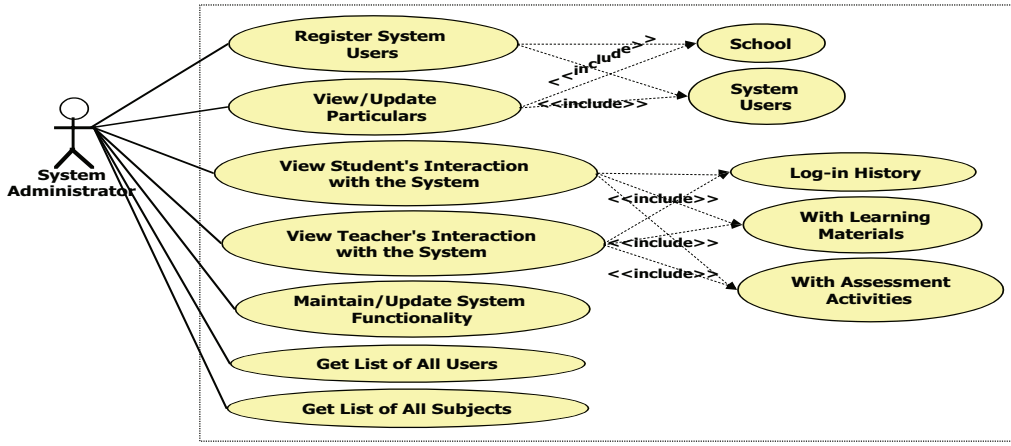

Fig. 5.6: Use Case Diagram for System Administrator Role

5.5.5 Content Administrator

Since learning materials are centrally created and uploaded into the system, only few people are needed to perform this creation and upload, we define this role as a "content administrator". As summarized in figure 5.7, a content administrator will perform the following specific functions in the system:

- Register/create subject to the system
- Enroll users to a subject
- Update subject information
- Create subject syllabus
- Create subject chapter
- Update subject chapter information
- Create chapter topic
- Update chapter topic information
- Create chapter exercise
- Update chapter exercise information
- Create topic exercise
- Update topic exercise information
- Create self test questions
- Create answers to self test questions

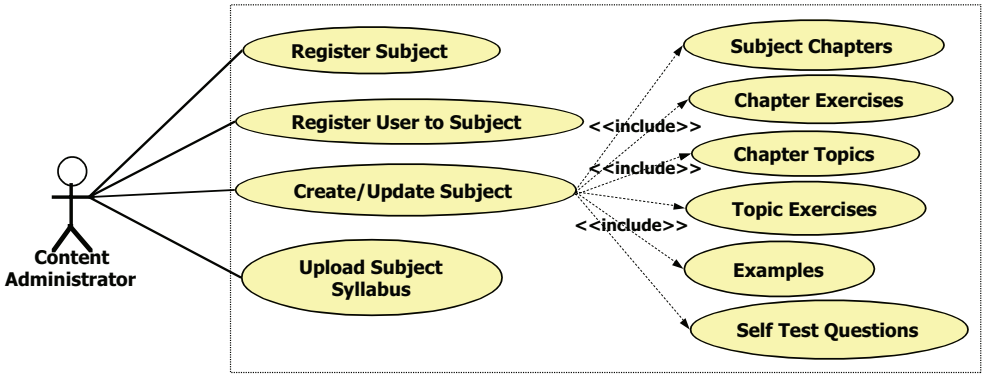

Fig. 5.7: Use Case Diagram for Content Administrator Role

5.5.6 MoEVT Officer

MoEVT officer is a user from the Ministry of Education and Vocational Training (MoEVT). This is the role for monitoring the progress of the e-LMS system and viewing contents available in the system. MoEVT has educational center offices at regional and district levels in Tanzania. The aim of educational centers is to assist in providing important services closer to remote secondary school. These offices are well equipped with resources like telephone, electricity and computer. MoEVT has also provided Internet connectivity to some educational centers and planning to have all centers be provided with the Internet. MoEVT officers will come from Ministry head quarter and/or from these educational center offices. MoEVT officer will perform the following specific functions in the system, and as summarized in figure 5.8:

- View and/or download learning materials
- View and/or download assessment questions
- View and/or download reference answers for exercises
- View system user's logins history
- View student's interaction with learning materials history
- View student's interaction with assessment activities history

5.5.7 Guest User

The guest user represents any user who is not registered in the system. This category is essentially for motivation purposes. Guest user will not get the rights/privileges like registered users. The usage of the system will be limited. He/she will be allowed to view a list of subjects available in e-LMS, table of contents, syllabus, objectives of the subject if any is available and any other information relevant to the public. Figure 5.9 is the use case diagram for a guest user.

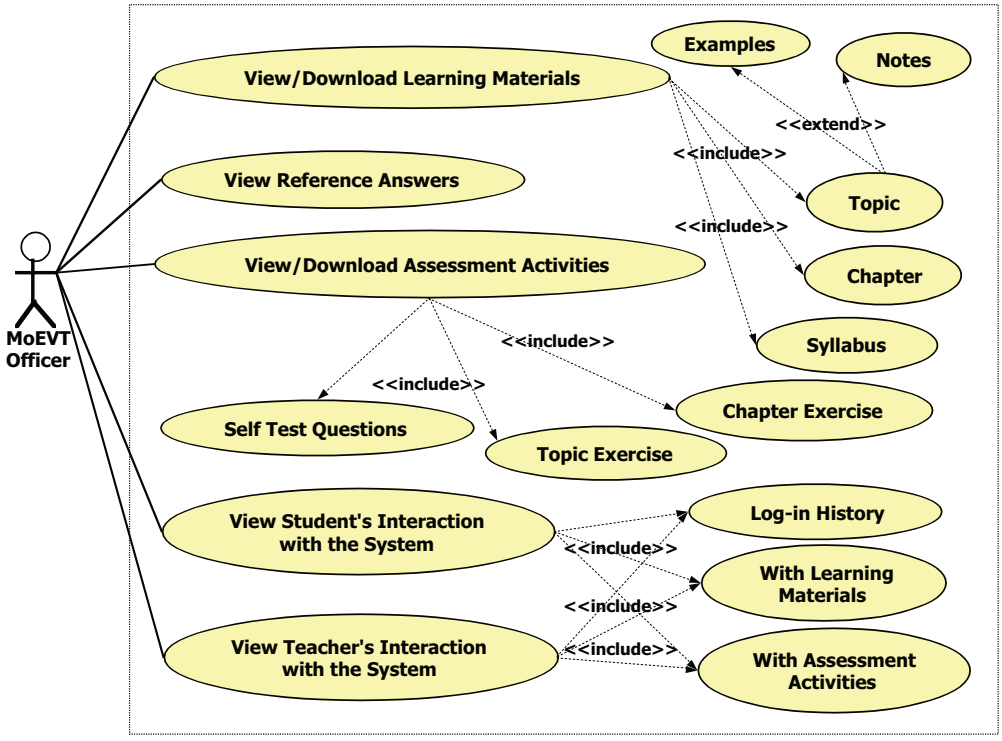

Fig. 5.8: Use Case Diagram for MoEVT Officer Role

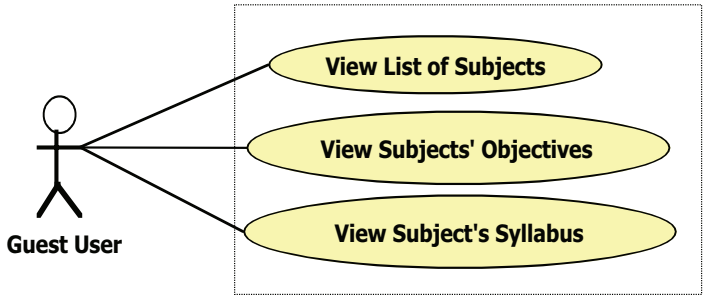

Fig. 5.9: Use Case Diagram for a Guest User

5.6 TECHNOLOGY AND STANDARDS

The e-learning management system is developed based on open source software Web based technologies and standards.

5.6.1 Web Based Technologies

Most of these Web based technologies and services are free and meets the World Wide Web Consortium (W3C). The ones to be used are:

- HTML, XHTML, CSS and JavaScript browser scripting language for interactivity
- PHP server scripting language, Apache Web server and MySQL database engine
- Extensible Mark-up Language (XML) for data description, structure, store and interoperability

5.6.2 Sharable Content Object Reference Model (SCORM)

The e-LMS will stick on to standards and the Sharable Content Object Reference Model (SCORM) is the standard to be adopted. The e-LMS will be a SCORM-compliant LMS in order to properly deliver and track SCORM-compliant learning content as it has been applied by SumTotal Systems (2003 – 2005).

SCORM is a suite of technical standards that enable Web-based learning systems to find, import, share, reuse, and export learning content in a standardized way. The SCORM is a conceptual model describing how to manage, package and deliver learning information so that it can be easily shared on the Internet. As shown in figure 5.10, the basic overview of SCORM is that it assumes the existence of a suite of services called by some a “Learning Management System (LMS)” and by others a “Learning Content Management System (LCMS)” (Albert et al., 2004), and formerly called a "Computer Managed Instruction" system. In the SCORM world there is a set of services that launches learning content, keeps track of learner progress, figures out in what order (sequence) learning objects are to be delivered, and reports student mastery through a learning experience. During the evolution of the SCORM suite of specifications, a standardized way was needed for content to send information back and forth between the learner (content) and the LMS.

SCORM has two main parts:

- Content Aggregation Model (CAM) which is concerned on how to put learning content together so it can be moved and reused
- Run-Time Environment which is concerned on how the learning content is going to be launched and the learner’s progress be tracked and reported back

Albert et al. (2004) defined SCORM as a set of interrelated technical specifications built upon the work of the Aviation Industry CBT (Computer-Based Training) Committee (AICC), Instructional Management Systems (IMS) and Institute of Electrical and Electronic Engineers (IEEE) to create one unified “content model” and enable the re-use of Web-based learning content across multiple environment and products.

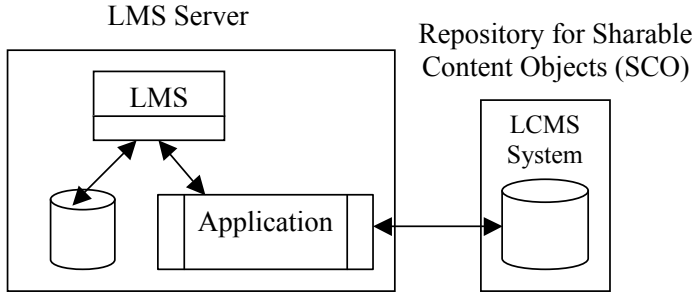

Fig. 5.10: An Overview of SCORM Implementation (Albert et al., 2003)

5.7 THE e-LMS SYSTEM ARCHITECTURE

The e-learning management system (e-LMS) will be a client- server, Web based system with a three-tier architecture. The system will consist of three major components: the MySQL database server that stores all the information and data needed including the means to link to the learning content repository, the apache application server that control the communication (basic system functionalities) and the client that is used by users in order to access data from the server (Web interface accessible via standard Web browsers). The three components will be networked to facilitate communication among them. Three-tier architecture has the following specific advantages (Kinshuk et al., 2003):

- It is easy to modify or replace any tier without affecting the other tiers
- Separating application and database functionality means better load balancing
- Adequate security policies can be enforced with the server tier without hindering the clients

As illustrated in figure 5.11, the architecture will consist of the following:

i. ***The Client Tier:*** also known as the user interface layer, will run the end-user's computer. The client provides the user interface for the Web-based application. It is a front-end layer. Using a computer, the user will access database through the Web server. The access to the computer will be possible by using created Web pages through any standard Web browser which support HTML, XHTML, JavaScript, and CSS Web technologies.

ii. ***The application Tier:*** will be responsible for interacting with the client in one side and the databases (database server and content repository) in another side. Application tier receives and processes data requests from the client, retrieves information (data) from database if any needed, generates a client response and store necessary data into the database. Application tier provide Web services and the data streaming services. Apache Web server to be used will be running in LINUX platform. A server side scripting language to be used is PHP and it will be used to connect to the back-end (database).

iii. ***The database Tier:*** is the place where data will be stored. The database server maintains the data needed for the Web application. It is a back-end layer. It will store data (including links to learning content repository) and control the basic system functionality. This tier may run on a separate server called the database server. MySQL database running in LINUX platform will be used in this case. Database server is responsible for providing a number of functionalities to the application layer (server), like; creation of the database, querying and updating it where required. Database server will also maintain data constraints and integrity and the restriction of unauthorized access. Multiple data interfaces, views, reports and the provision of backup and recovery will also be implemented.

Application server, database server and learning material repository will be centrally placed at the College of Engineering and Technology (CoET) of the University of Dar-es-Salaam (UDSM). Distributed users will be able to browse learning materials using any standard Web browsers through application server.

To increase availability and overcome lower bandwidth, Local server will be placed at Kibaha pilot site. Local server will get the replicated database from the main server. Users at kibaha will be able to access learning materials from the local server as well.

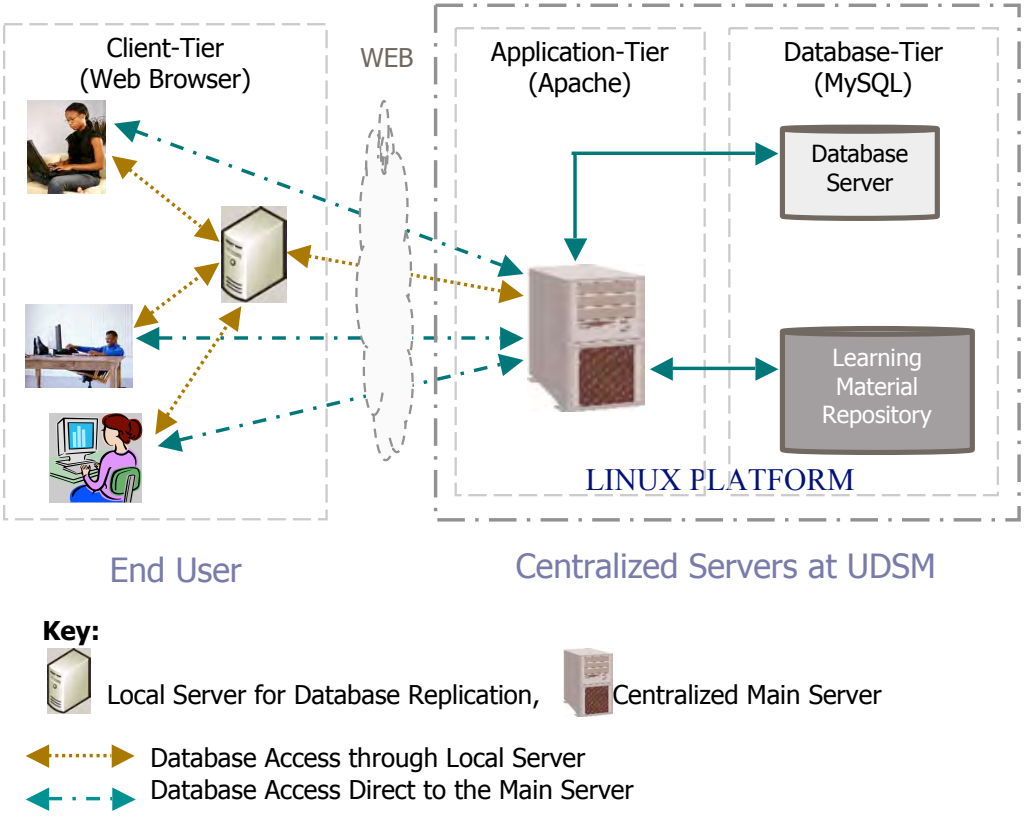

Fig. 5.11: The e-LMS System Architecture

6.0 CONCLUDING REMARKS

6.1 CONCLUSION

From what has been discussed in previous chapters the following concluding remarks can be made.

i) Open Source Software

Tanzania being a developing country can not afford the cost of commercial software. It is wise to effectively use the advantaged opportunities brought by open source community. There is a possibility of creating something concrete using open source software. In that case, we have decided the e-LMS system to be fully developed using OSS. Benefits of OSS as published by Hall (2008) include:

- Low initial cost: open source software is free to download
- Flexibility and customizability: one can modify the software whenever the need arises
- Extensive active user communities: participating in open source projects is a source of distinction among developers
- Multi-platform capabilities: many open source applications run on multiple platforms including Windows and Linux
- Adherence to standards: interoperability is a high priority for many open source developers
- Tendency to use and link to other open source software: including popular languages and platforms such as PHP and MySQL database

OSS to be used include Apache a World Wide Web open source server software, MySQL database management system (DBMS), PHP scripting language and OS LMS for customization, here Moodle and Claroline. Customization of OS LMS is however a challenging task since many of the present OS LMS are designed for higher learning institutions. This research is dealing with the lower education level that is secondary schools. We find very few features which directly suite our needs.

ii) Specific Objectives as Related to Research Questions

System requirement and specification phase is the base for the development of the e-LMS system. This is the phase where most important attributes for building an information system are identified and validated. If properly done, the process of development will not be stacked easily and it will be easily traced for modification. Development of an interactive e-LMS as the main objective has three specific objectives. This phase being a base has to provide partial answers of the research questions created for each specific objective before final implementation. Consistently, this research has three research

questions related to specific objectives. Research questions were created based on the following key services to be implemented by the e-LMS system.

Sharing of learning materials

The purpose of developing e-LMS is in facilitating sharing of contents. This is done through creating a three-tier architecture where learning materials will be centrally created and stored in a content repository. All users will have access to the centrally placed materials through a Web browser. Only one role "content Administrator" will be allowed to create and upload learning material to the system. Organizing e-LMS in a three-tier architecture is the partial answer for the research question number one (RQ1).

> [15]RQ1: How can learning materials content be made available and sharable among several students and teachers?

Availability as included in RQ1 is another issue of doubt due to high costs of the Internet. Availability of the database learning materials will be strengthened by mirroring the database and replicating full or part of the content from the main database to the local servers. A local server is planned to be servicing cluster of schools in nearby area. We need one local server for Kibaha secondary school and Wali-ul-Asr girls' seminary in Kibaha. In other words using Intranet network in education will reduce costs considerably and promote security of stored information and sharing of information from the database (Kamthan, 1998). As indicated in the e-LMS system functions, database mirroring and replication will be handled by the database management system (DBMS) through proper settings. Specific objective for the research question number one is hereby stated as:

> [16]SO1: To develop a module so as to enable creation, storing, publication and sharing of learning materials

Security Issues

A critical issue in databases is security. The risks of a database system include unauthorized access to confidential data, unauthorized modification of data and loss of availability of the data ([17]NISCC, 2003). Data here means administrative information used by the database and all other information stored in the database including learning materials. Research question based on security issues is:

> RQ2: In which ways can the e-LMS database and the information stored inside, including learning materials be secured?

There are measures to be implemented in the database to counter these threats. These measures as suggested by NISCC (2003) have been indicated in this research to answer research question number two (RQ2) as follows:

[15] RQ – Research Questions
[16] SO – Specific Objective
[17] NISCC - National Infrastructure Security Co-ordination Centre

- Identification and authentication of users is one way where username and passwords will be used. In this research, the e-LMS system validates logins information (username and password) entered by the user in order to use the system and allow the registered user to login/out to the system.

- Access control is another way of securing the database and the stored information. In this research, access control is being taken care of by organizing users by role-based access control. Each user will be assigned the role and the system will display available resources for that role. Many of the roles assigned have "read only" or "view" capability except for "content administrator" who creates and uploads learning material. We have minimized number of roles to upload data in the system for integrity purposes.

- Database backups and recovery is another way of proving security. This will be done by the e-LMS system as a hidden function by proper settings, hence included as a system function. Mirroring of the database and replication to local server is another way of backing-up the database.

The e-LMS system is also considering security of the database server itself. This is limiting access not only to the information stored on it, but access to the server having the database. Database back-end should never be on the same machine as the Web server, not only for security but also for performance (Wiedman, 2008). Again a three-tier architecture for the e-LMS separates database server from the users (client-tier) using a Web server (application-tier). Only the address of the Web server will be allowed to access the database server. Specific objective for the research question number two (RQ2) is hereby stated as:

SO2: To develop mechanisms for protecting the database and the information stored, as well as manage users of the system and the workflow of the learning materials

Evaluation and Assessment Issues

Evaluating the usage of the e-LMS by the targeted users is a very important aspect. The system is being developed for the stakeholders to use. The research has provided the mechanism for tracking several events for future evaluation of the usage of the system which answers research question number three (RQ3):

- Tracking of user login and logout, to evaluate the number of users who will log in into the system
- Tracking of student's interaction with learning materials. Students are number one targeted users. The interaction with learning materials will indicate that students are really using learning materials stored in e-LMS

RQ3: How can the e-LMS monitor the learning progress of the students, as well as the student's understanding to the visited learning materials?

Tracking history of student's logins especially based on the individual school will help in evaluating the performance improvement level of the school in National Examinations. Once the system is implemented, and if logins and interactions with learning materials will not be convincing, teachers and school administrators will be able to motivate their students to use the system.

Assessment is one of the main techniques for checking and monitoring students' level of understanding the knowledge read from the learning materials (Avgeriou et al., 2003). Learning materials are accompanied with a number of exercises to make students assess the knowledge she/he has obtained. The e-LMS is providing tracking of student's interaction for this purpose. The system also provides self test assessment, where by a student will be asked self test questions in multiple choice forms related to selected chapter/topic materials. He / she will answer questions and send to the system. The system will return student's performance right away. Specific objective for the research question number three (RQ3) is hereby read as:

SO3: To develop ways of evaluating students' learning progress through e-LMS, including means of assessment functions

We can see that only two needs were identified during requirement analysis, namely the need to have more learning materials and more assessment questions. But, coming to the implementation in order to meet these needs, there are lots of considerations to be taken care of and they have impacts which refer to a complex system.

iii) Experience with Participatory Research Methodology

The significance of participatory action research methodology is very crucial not only to social and medical sciences, but even in Information Systems (IS) development. Experience gained in requirement finding reveals that, people are very much willing to contribute their views when it comes to issues for their own or public sake benefit. The students' registration database developed for Wali-ul-Asr girls' seminary created a good relationship among us researchers and the school staff. School teachers were free and part and parcel even when participating for the e-LMS development. Teachers and students were open-minded when identifying problems facing Tanzania secondary schools education system. Participatory action research methodology is also a way of exchanging knowledge, that is, users giving their experiences about their system they are in and researchers giving new suggestions and techniques to improve that system. Knowledge introduced on how the power of ICT can effectively be used to improve social lives to our two pilot schools. Wali-ul-Asr and KSS have created a noticeable motivation and build interest on the coming technological change ahead of them.

iv) Value of Licentiate Programme

The licentiate programme was totally a new thing to me. This is because there is no such a programme at the University of Dar es Salaam. However, I happen to like the programme very much because of the following I have experienced and which have helped me considerably:

- Clear and open plan of the programme especially the need to participate relevant courses of the research area involved. In this research, some few courses like Web based technologies (HTML, XHTML, JavaScript, PHP), Web page design and research methodology course were and still are very helpful to my research
- Acceleration towards PhD thesis is again an added advantage instead of having a solid programme direct to PhD completion

Taking licentiate degree as a transitional degree to pursue doctorate studies to my opinion is very much worth. In Swedish it is called "*Teknologie Licentiat"*, usually abbreviated as "*Tekn. Lic"*.

6.2 MAIN CONTRIBUTION

i) Contribution Academically in Methodological View

Development of an interactive e-Learning Management System for Tanzanian secondary schools is incorporating a number of methodologies:

OOSA &D, MDA and PAR

The contribution towards this is mainly on how to effectively exploit the power of modeling as applied in OOSA&D and MDA using UML together with participatory action research methodology in a real-time development of software. We can see that the requirements and specifications for e-LMS to be developed are contextually specific to Kibaha secondary school and Wali-ul-Asr girls' seminary, pilot schools. Modeling have been used to communicate key system characteristics to various stakeholders of Tanzania education system at pilot schools and at the MoEVT (students, teachers, headmaster/headmistress and Ministry officials) from early stages and come up with the requirements of e-LMS. Participatory action research methodology is a continuous process. It will be practiced until a functional system is obtained. Participatory action research methodology is a new technique in problem solving especially in our College of Engineering and Technology (CoET) of the University of Dar es Salaam (UDSM).

The approach of using OOSA&D in developing functional system like e-LMS is a new methodology to be introduced in the faculty of Electrical and Computer System Engineering (ECSE) and the College of Engineering and Technology (CoET) at large. For a long time only one approach was employed, that is using structured approach in system analysis and design. Many non-Governmental and Government organizations are employing Software Engineering (SE) in their business applications. With this new methodology, CoET will be able to assist the public in such related works. Having

varieties of software development techniques, ECSE can easily establish SE department, which is not there as well as establishment of new research area in software development at ECSE and CoET.

One of the obligations of higher institutions is to disseminate knowledge to others. Being a lecturer under the department of Computer and Systems Engineering (CSE), ECSE, CoET, my contribution to the CoET will be through building capacity to learners of this area.

Furthermore, object oriented system analysis and design with UML gives the e-LMS Platform Independent Model (PIM). Being the added contribution, the research continues more on applying MDA transformations to obtain e-LMS Platform Specific Model (PSM) for implementation.

Use of Open Source Software

The use of open source software is starting to be known to the UDSM community and other higher institutions. UDSM for many years has been using blackboard LMS which is a commercial platform. Due to higher costs UDSM is now customizing open source LMS to replace commercial platform after completion. The good part is that many OS LMS are for higher instructions. It is easy for UDSM to customize these OS LMS. Employing open source software to lower level of secondary schools is a commendable thing because we are transforming OS LMS for higher institutions to make them suite lower level of education, who majority of them have very little knowledge in ICT.

ii) Contribution to the Public

International Conference and Journal Papers

So far we have managed to present two papers in international conferences. These papers are included in International Journals. As indicated in Appendix A (A.2 and A.3), our first paper is titled "An Interactive e-Learning Management System (e-LMS): A Solution to Tanzanian Secondary Schools' Education" and our second paper is titled "Strategies for Developing e-LMS for Tanzania Secondary Schools". All papers are included in the conference proceedings of World Academy of Science, Engineering and Technology (WASET) and in International Journal of Social Sciences (IJSS). Any one who is interested can make them as a reference.

Open Source Community

Modified source codes for e-LMS will enter into the open source world such that any one can modify and re-use them. This is a contribution to the open source community. Customization of open source LMS platforms is being used to develop a system which is optionally fitted in our specific context.

e-LMS Model for Tanzania Secondary Schools

Dynamic and Interactive e-LMS is a special gift to Kibaha secondary school and Wali-ul-Asr girls' seminary, and may be latter to Tanzanian secondary schools community as a

whole. It is the first one to be introduced and developed so far. The end product will be a quality based context done at our environment. Tanzanian secondary schools stakeholders from pilot schools will be part and parcel of it from scratch. At the end of the PhD research we will have an e-LMS model for secondary schools at Kibaha which was not there.

6.3 WORK DONE SO FAR

Identification of the methodologies to be used in developing e-LMS system was among the major work done in the licentiate thesis. A thorough theoretical study of the identified methods was given a priority, sometimes even "learning by doing" approach was employed whenever it was needed. Being confident with the methodology to be used gives guidance on steps towards developing software and consistent flow of development will be reached.

In software development, successful Information System is a subject of frequent evaluation and revision within a framework known as System Development Life-Cycle (SDLC). SDLC is the basic approach for most software development methodologies. System's life cycle for e-LMS development consists of four principal phases:

- System Requirement and Specification phase
- System Analysis and System Design Phase
- System Implementation Phase
- Testing Phase

System requirement and specification phase is an important area covered fully in the licentiate report. This is because at this phase all major information for designing a new system is being addressed. System requirement and specification phase was preceded by database planning where strengths and weaknesses for the current secondary schools education system were evaluated and the main objective was identified. It was then followed by describing the scope and boundaries of the database application and the major user views in the system description as it has been suggested by Connolly et al. (2005). User view defines what is required of a database system from the perspective of a particular role (for example student, teacher) or application area (such as managing subject). A user view also defines what is required of the database system in terms of the data to be held and the transactions to be performed on the data (Connolly et al., 2005).

We have seen requirement collection and analysis as a process of collecting and analyzing information from different stakeholders of the Tanzania education system that is to be supported by the database system, and using this information to identify the requirements for the new system. These requirements were described in documents collectively referred to as requirement specification for the new database system. The information collected at this stage was converted into a more structured statement of requirements. This is use case model as applied by Unified Modeling Language (UML) (Connolly et al., 2005).

6.4 FUTURE WORK

System analysis and system design, system implementation and testing phases are future works for PhD completion. System analysis will involve analyzing the system requirements and identifying concepts of the system, creating the conceptual diagram, identifying system operations through system conceptual diagrams and system operations contracts. System design will involve creation of interactive diagrams (sequence and collaborative diagrams), design class diagram and component diagram in OOSA&D as related to platform independent model (PIM) of MDA. The platform specific model for e-LMS (physical database) will be reached after involving mappings using XMI and data from the open source LMS platform to be customized.

Connolly et al. (2005) state that system (database) design phase, and application designs are parallel activities of database SDLC. Application design is the design of the user interface and the application programs (coding) that use and process the database. Application design involves designing the application programs that access the database, designing appropriate user interface to the database system and designing the transactions (that is, the database access methods) (Connolly et al., 2005). In this thesis, application design will be extended to implementation phase.

Security issues to the e-LMS will highly be considered in future work during system analysis & design and implementation phases. All areas of security which include; server security, user-based authentication security and session security will be incorporated. Effectiveness of applying learning management system to Tanzanian secondary schools at Kibaha is another crucial area to be highlighted in the future work. The affordability of using LMS against the current education system in terms of cost will also be covered.

Finally, the developed e-LMS will be tested for its functionality in the computer lab before implemented at Kibaha secondary school and Wali-ul-Asr girls' seminary. Connolly et al. (2005) highlighting by saying that testing should cover usability of the database system, and an evaluation should be conducted against a usability specification. Examples of criteria that can be used to conduct the evaluation include:

- Learnability – How long does it take a new user to become productive with the system?
- Performance – How well does the system response match the user's work practice?
- Robustness – How tolerant is the system of user error?
- Recoverability – How good is the system at recovering from user errors?
- Adaptability – How closely is the system tied to a single model of work?

After completing testing the developed e-LMS in the computer lab, then as mentioned, database will be ready to be used by two selected pilot schools, that is, Kibaha secondary school and Wali-ul-ASR girls' seminary at Kibaha, Pwani region.

6.5 TanSSe-L

Every system has a unique name. **Tan**zania **S**econdary **S**chool **e-L**earning (TanSSe-L) is the name given to the e-learning system we are developing. The name reflects the system ownership of all Tanzanian secondary schools including Government and private secondary schools (community, mission, individual).

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APPENDIX A: JOURNAL PAPERS

A.1 SUMMARY OF THE PAPERS

Two conference papers were presented in international conferences and included in International Journals.

Paper I: titled "An Interactive e-Learning Management System (e-LMS): A Solution to Tanzanian Secondary Schools' Education" was presented on May 2007 and included in the conference proceedings of World Academy of Science, Engineering and Technology (WASET), 21st International Conference on Computer, Electrical, and Systems Science, and Engineering, CESSE, Volume 21, May 2007, Vienna, Austria, ISBN 978-975-01752-0-6. This paper presents the e-readiness survey results from secondary schools in Tanzania and Tanzania as a whole. The paper also suggests how Tanzania can make use of the few present ICT resources to support and improve teaching and learning functions to improve performance and acquisition of knowledge by using e-Learning Management System (e-LMS). This paper is fully shown in A.2 of this appendix A.

"An Interactive e-Learning Management System (e-LMS): A Solution to Tanzanian Secondary Schools' Education" paper is included in World Academy of Science, Engineering and Technology (WASET), International Journal of Social Sciences (IJSS) Volume 1 Number 4, Pages 250 – 253.

Paper II: titled "Strategies for Developing e-LMS for Tanzanian Secondary Schools" was presented on October 2007 and included in the conference proceedings of World Academy of Science, Engineering and Technology (WASET), 26th International Conference on Computer, Electrical, and Systems Science, and Engineering, CESSE, Volume 24, October 2007, Nice, France, ISSN 1307 – 6884. This paper presents strategies of developing e-LMS. The paper shows the importance of integrating action research methodology with the modeling methods as presented by model driven architecture (MDA) and the usefulness of Unified Modeling Language (UML) on the issue of modeling. It also shows the benefit of MDA when used along with the development based on software development life cycle (SDLC) process, from analysis and requirement phase through design and implementation stages as employed by object oriented system analysis and design approach. The paper also explains the employment of open source code reuse from open source learning platforms for the context sensitive development of the e-LMS for Tanzania secondary schools. This paper is fully shown in A.3 of this appendix A.

"Strategies for Developing e-LMS for Tanzanian Secondary Schools" paper is included in World Academy of Science, Engineering and Technology (WASET), International Journal of Social Sciences (IJSS) Volume 2 Number 3, Pages 145 – 150.

A.2 PAPER I

An Interactive e-Learning Management System (e-LMS): A Solution to Tanzanian Secondary Schools' Education

[1]Kalinga Ellen A., [2]Bagile Burchard R. B., and [3]Lena Trojer

Abstract— Information and Communications Technologies (ICT) has been integrated in education in many developing and developed countries alike, but the use of ICT in Tanzanian schools is dismal. Many Tanzanian secondary schools have no computers. The few schools with computers use them primarily for secretarial services and computer literacy training.

The Tanzanian education system at other levels like secondary school level has to undergo substantial transformation, underscored by the growing application of new information and communication technology. This paper presents the e-readiness survey result from secondary schools in Tanzania. The paper also suggests how Tanzania can make use of the few present ICT resources to support and improve teaching and learning functions to improve performance and acquisition of knowledge by using e-Learning Management System (e-LMS).

Keywords— e-Learning, ICT, Object-Oriented, Participatory design,

I. INTRODUCTION

TANZANIAN secondary schools in rural areas are geographically and socially isolated, hence face a number of problems in getting learning materials and quality teachers. The schools face three critical issues that are global in perspective, but remain focused on the learners' needs. These are shortage of teachers, quality of teaching and the capacity of schools in terms incentives/motivations [7]. The focus now in Tanzania to improve teaching and learning is to raise the standard of teachers' preparation programs, increase degree attainment of teachers and increase classroom strategies in service training. The drive can only be effective by providing support to teachers by providing adequacy access to basic up-to-date information resources like textbooks and reference materials. Also laboratories for science subjects need to be well equipped and teaching aids available. Even some regional schools can not attract good teachers because of opportunities in their locality and pay scale. The situation is aggravated by the low number of committed and competent teachers compared with demand.

The Government is making big effort to improve the situation but is overwhelmed by the rate of increase secondary schools and students, which stretches beyond limit the available teachers and teaching and learning resources. These constraints result in poor performance and low morale, particularly in rural and in some urban schools. Performance is more critical in science and mathematics subjects in rural schools.

One of several ways to encounter these constrains is to make use of ICT. The National ICT Policy of Tanzania [9] [8] highlights that ICT encompasses telecommunications services, computers and associated peripherals, Internet services, e-mail, fax, broadcasting, TVs and other media . One of the objectives of the National ICT Policy of Tanzania is to use ICT to improve the quality of delivery of education and training in all areas including distance learning. Achieving these objectives is however a process.

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II. TANZANIA SECONDARY SCHOOLS' E-READINESS SURVEY

E-readiness studies were conducted in Tanzania showing that the country is gradually entering the global information society, however the available resources limit the pace considerably. This study is part of a bigger project of ICT for e-learning in rural secondary schools.

Ten locations were chosen as pilot study areas, where six schools were selected in each area. These were visited and surveyed. The locations were: Bagamoyo, Iringa, Kibaha, Kilwa, Mkuranga, Moshi, Morogoro, Mwanga, Songea, Mbeya, Dodoma and Arusha**.** The survey covered e-readiness of schools, data providers and that of the relevant Ministry. The end selection of a pilot area was based on the following criteria: vicinity and accessibility from each other and teaching science based subjects.

A. Data Communication Service Providers

Twaakyondo, Bhalalusesa and Ndalichako [10] found that Tanzania through its regulatory authority the Tanzania Communication Regulatory Authority (TCRA) has provided license to six companies to provide Public Data Communication Services. The licenses did not include provision of voice services. Only two companies were initially granted exclusive rights to provide wired network telecom services - one in each part of the republic.

Yonah [12] indicates that TTCL/SIMUNET is implementing 10 zonal Points of Presence (PoP), 27 at regional level and over 70 at district level. The intention being to allow Internet-access connectivity by dial-up to become local calls in many places in Tanzania. There are five licensed mobile phone operators that use the services of fixed network companies for interconnection and for backbone services.

There are a number of licensed Internet Services Providers (ISPs) that is growing day by day. These are either using the Point-of-Presence or satellite connection.

B. Availability of Computers

In the study made to assess e-readiness in schools the availability of telecommunications services, computers and associated peripherals and Internet services to the schools were observed. The results show that many schools have acquired computers through own initiative or effort using school funds or donation from donors or provided by the Government. Many schools have landline telephone connection but only very few manage to have Internet service connected because of operational costs.

Table I and fig. 1 show a summary state of availability of computers for the 71 secondary schools that were surveyed in 10 regions out of a total 21 regions of Tanzania Mainland. Assessment of availability of computers was considered to be fundamental because computer is a basic resource to facilitate use of ICT. It is important to note however that the student population in such schools range from 400 to 1500. This is clearly a desperate situation.

Table I: Computer availability summary

Number of Computers in a school	**Number of Schools**
0	19
1 – 3	25
4 – 15	11
≥ 16	16

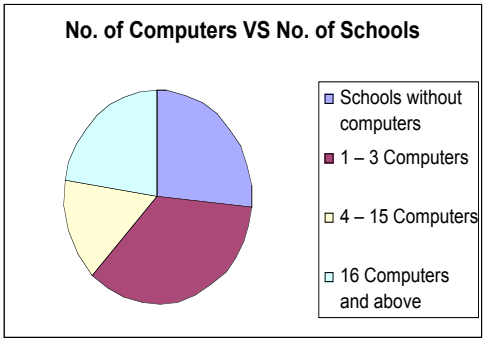

Fig. 1: Pattern of distribution of computers in schools

It was observed that many schools have desire for and are making efforts to procure computers. The adequacy of infrastructures, logistics and competent personnel in schools is a major constraint to the availability and use of ICT in schools. Addo [2] considers the critical requirements to be a computer laboratory, a school library, electricity, a telephone and adequate security to ensure safekeeping of computer systems. The study shows that of the 71 surveyed schools 73 % have at least one computer, 35 % have one to three, 16 % have 4 to 15 computers and 22 % have more than 16 computers.

III. E-LEARNING PROJECT COMPONENTS

There have been efforts to improve secondary education in Tanzania using ICT through several projects. Some ended with static websites like: http://www.distancelearning-tz.org. Such websites are accessible to students in the urban areas where there are Internet cafes.

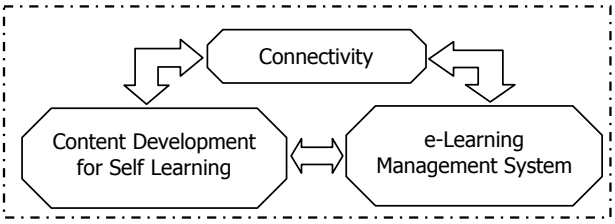

Fig. 2: e-Learning Project Components

To complement such efforts in a more dynamic way the University of Dar-es-Salaam through its College of Engineering and Technology conceived a research project to develop a tool to enable ICT support rural secondary schools. The focus is to enable ICT support with teaching materials, which are user friendly, facilitating self learning and information sharing, starting with science and mathematics. The success of this research work rests on realizing three basic pillars as shown in fig. 2: Establishment of suitable and effective connectivity and configuration, development of a context centered platform which includes e-learning content management system based and development of the repository structure for local content materials to self learning environment and sharing. To minimize operational costs open source platform has been chosen.

Commercial use of ICT in e-learning is gaining momentum in Tanzania particularly when foreign universities use local universities and institutions to deliver their programs. There are local ventures but with limited scope. There is also a teleconference facility [5], a project funded by World Bank. But the cost for using the facilities is very high. Another African Virtual University (AVU) project established by the World Bank in 1997 involved a total of 31 learning centers established in 17 African Nations [6]. The benefits of using ICT for e-learning includes cost reduction, wider access beyond physical walls classrooms, performance improvement, quality enhancement and creation of new products and services.

IV. DEVELOPMENT OF E-LMS

E-learning is an attentive concept, subject to wide variation in practice, which has become a common mode of education delivery worldwide. Akeroyd [3] elaborates this by stating that the extreme case is the use of the web technology to facilitate the whole cycle of learning from initial sign-on to final certification. There will be a range of operations in between, with no or little physical interaction among learners. Hence, the World-Wide-Web (WWW) opened a new dimension to computer based training where learners can learn from anywhere, anytime with possibilities for huge cost savings in corporate training. Online learning has created new dimension to opportunities for collaboration among academic institutions and beyond. Access to academic resources is at a level that remained a dream two decades ago. The beneficiaries are town duelers in most developing countries.

The need for learning management systems (LMS) being developed is underlined by Watson et al., [11] who argues that the e-learning industry, which includes different groups of users and knowledge requirements, needs effective manageable system to monitor the learners', learning, measure it and provide reports on learning efficiency. Hence, constant tracking of the learners' actions and online tests results can be done. LMS provide a technological, parameter driven framework to allow individuals develop and deliver learning content, to interact with students and to facilitate open discussion. Advancing LMS will support a range of administrative functions relating to course delivery and administration to enable e-learning such as content delivery, performance tracking, management of learners and their courses and students' collaboration.

A basic LMS is a Web application where the learner logs on and accesses the courses allocated to her/him. While the learner is going through the courseware, the LMS stores information about the learners' interactions, such as scores and answers to questions. LMS use this information to analyze how well the learner is performing, and are able to provide reports to the administrators and course tutors. Hence a LMS should contain an interface for managing users, adding/deleting new learners, organizing learners and allocating access rights/courses to uses and user groups.

The LMS to being developed is model driven and web-based platform in order to carter for wide access to a big number of rural secondary schools in different regions. As shown in fig. 3, it is based on three-tier architecture and consists of the following:

Client-Tier: The user interface running in a web browser in the computer,
Application-Tier: Apache web server will be used running in LINUX platform and
Database-Tier: MySQL database running in LINUX platform.

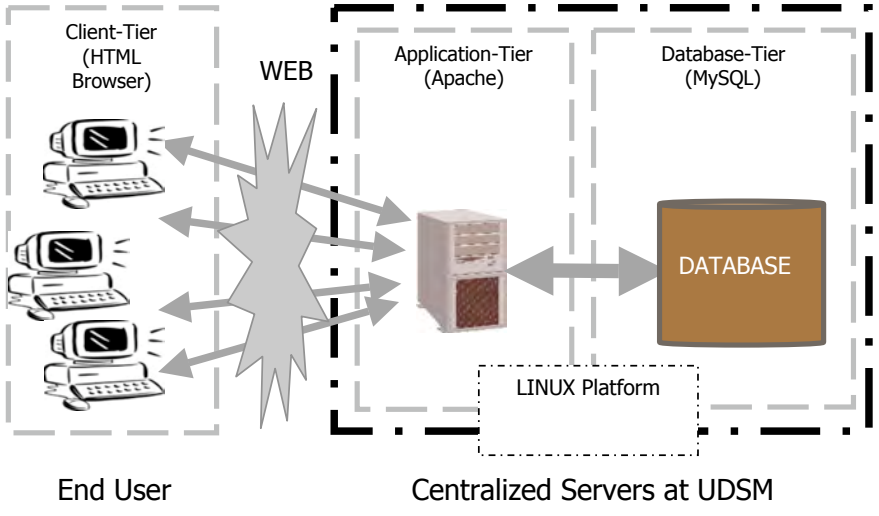

Fig. 3: e-LMS Three Tier Architecture

The e-learning materials will be centrally stored at the database server with functionality of mirror imaging to localities of school. Distributed users will be able to browse learning materials using any standard internet browser through application server. Security of information in the central server and its mirrors and that in schools is an issue that is still being considered. Both the central application server and the database server will be located at the University of Dar es Salaam, College of Engineering and Technology.

V. METHODOLOGY FOR E-LMS DEVELOPMENT

Software engineering principles applicable in software development shall be employed in the System Development Life-Cycle (SDLC). Open Source Software (OSS) platform based on LINUX operating system and Web based technologies like HTML markup language, Java Scripting language, Cascading Style Sheets (CSS), PHP server side scripting language, MySQL database management system, and Apache web server will be used. Understanding of database management systems (DBMS) and data modeling is critical.

The importance of considering users in developing computer systems in general has been recognized since the 1970s [1]. As a primary source of information our approach in developing e-LMS is participation of users from the analysis stage to implementation. Questioners, physical observation and group discussion with students, teachers and school administrator is employed. The students/learners remain the focal point for users of e-LMS, hence it should satisfy their needs and resolve their problems [4]. Others are teachers, school administrators, parents and education official from the Ministry.

Many of the students, teachers and administrators are not aware of the technology in ICT in education, though some are in contact with at least computers. With this respect, gathering user-requirement for a platform has also taken the approach to base on the user requirements on broader fundamentals, that is, secondary source of data. This includes other researches' reports, recommendations from an analysis of current learning articles, journals, published and unpublished papers, as well as the investigation on the existing learning models from open source learning management systems.

An Object-Oriented system development approach is adopted in this research. The object-oriented analysis (OOA) technique used is based on the Model Driven Architecture (MDA) using Unified Modeling Language (UML) techniques for the design. Several types of diagrams such as use-case (plus high level and extended use cases), sequence, domain, collaboration and design class diagrams will be employed. For a web-based system, an extensible markup language (XML) technology is applied, which maps with the UML to create a dynamic, interactive web application. Modeling will be obtained by mapping UML and XML schema. A high-level design process will follow that evolves into a more detailed design i.e. implementation and testing stage. This will involve code generation using high-level language. Code from open source software will be used as a base.

VI. CONCLUSION

The use of ICT provides innovative ways to complement the traditional student-teacher interaction worldwide to optimize resource usage, sharing and collaboration. Therefore, the development of e-learning facilities for rural areas of Tanzania has high national priorities and hence relevance. Application of ICT in e-learning that is accessible in remote and rural schools will improve the performance of students in such schools in rural areas as well as raising morale for teachers and students.

A web-based e-learning management system for Tanzanian secondary schools is necessary and must address the peculiarities of local conditions of schools so that ICT resources can be used to improve teaching and learning functions accessible beyond urban communities. The e-LMS being developed will allow creation, storage, re-use and delivery of digital learning material, and will also manage these resources with users from central object repository. To affect the e-LMS, connectivity has to be established to secondary schools. Achieving the connectivity other services such as e-healthy, e-commerce, can be introduced in the surrounding areas.

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A.3 PAPER II

Strategies for Developing e-LMS for Tanzania Secondary Schools

[1]Kalinga Ellen A., [2]Bagile Burchard R. B., and [3]Lena Trojer

***Abstract*—** Tanzania secondary schools in rural areas are geographically and socially isolated, hence face a number of problems in getting learning materials resulting in poor performance in National examinations. E-learning as defined to be the use of information and communication technology (ICT) for supporting the educational processes has motivated Tanzania to apply ICT in its education system. There has been effort to improve secondary school education using ICT through several projects. ICT for e-learning to Tanzania rural secondary school is one of the research projects conceived by the University of Dar-es-Salaam through its College of Engineering and Technology. The main objective of the project is to develop a tool to enable ICT support rural secondary school.

The project is comprehensive with a number of components, one being development of e-learning management system (e-LMS) for Tanzania secondary schools. This paper presents strategies of developing e-LMS. It shows the importance of integrating action research methodology with the modeling methods as presented by model driven architecture (MDA) and the usefulness of Unified Modeling Language (UML) on the issue of modeling. The benefit of MDA will go along with the development based on software development life cycle (SDLC) process, from analysis and requirement phase through design and implementation stages as employed by object oriented system analysis and design approach. The paper also explains the employment of open source code reuse from open source learning platforms for the context sensitive development of the e-LMS for Tanzania secondary schools.

***Keywords*—**Action Research Methodology, OOSA&D, MDA, UML, Open Source LMS.

I. INTRODUCTION

THERE is a lot of results in the field of software engineering concerning the question of how to represent systems and how to build a base for communication between the developer and the user of a software system [24]. In order to manage the return investment in ICT for education, here referred to e-learning management system (e-LMS), it is essential that the benefits, risks and cost effectiveness of using new technology and new media are well understood in the context of application. An effective approach is to involve users in establishing the expected use of ICT and the benefit of it in education.

The e-LMS to be developed is for Tanzania secondary school members, who many of them are not aware of the ICT technology in education. Modeling methodology is the best way to create visualization of the system to be defined. With modeling, complex and real-world systems can be somehow understood, qualities of the system can be predicted and communication with stakeholders concerning the key characteristics will be promoted [2]. Models are developed as a way of creating a base for implementation of the physical system and testing.

Integrating the action research methodology with the whole issue of employing Model-Driven Architecture is of significance. Action research methodology and modeling support each other, when it comes to the software development for users.

The rest of this paper is organized as follows: section two elaborates on the strategy of using action research methodology in developing e-LMS. Section three focuses on the object oriented system analysis and design (OOSA&D). Section four gives the employment of Model-Driven Architecture and the use of

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the Unified Modeling Language (UML) as the documentation modeling language specified by OMG. The strategy of creating Platform Independent Model (PIM) for e-LMS and means of transformation of PIM into Platform Specific Model (PSM) is in section five. Another strategy is customization of the selected open source LMS platform based on e-LMS PIM is introduced in section six. Section seven gives the need for replication of the e-LMS database. Finally the paper will give the conclusion.

II. ACTION RESEARCH METHODOLOGY

The knowledge on how ICT and its application can improve social and economical life of people is not very much known to many of the Tanzania community in general. Although Tanzanian secondary schools may have and be in contact with computers, it doesn't mean that they really are aware of the impact of ICT when effectively used towards improving performance. Coming to the issue of developing a LMS for their use, the issue of lack of knowledge if not carefully considered, the utilization of LMS may be very minimal if at all not completely used. The emphasis of action research methodology is to be a methodology which accompanies the introduction of technology as well into organizations and learning. Action research represents a specific form of knowledge generation thus, with its methodology the understanding of the use of e-LMS will be possible and hence increase assurance towards its utilization.

The importance of considering users in developing computer systems has been recognized since the 1970s (Abel et al., 1998) [1]. O'Brien (2001) [13] stated that action research or sometimes known as participatory research is "learning by doing"-a group of people identify a problem, do something to resolve it, see how successful their efforts were and if not satisfied, try it again. Walker and Hermann [18] also argued that participatory design and continuous business improvement can be brought together in a framework which presents a set of different phases in a cyclic order. In the Nordic countries the "Scandinavian model" was introduced in the middle of the 80s [20], introducing a participatory approach involving users for context sensitive and robust IT system solutions. Coming closer to a sub Sahara African context the action research conducted in the presented project is more likely linked to participatory rural appraisal (PRA) introduced by Chambers (1997) [4] and Rydhagen (2002) [21].

Users mainly students, teachers and school administrators are considered to be the primary source of data in such that they will be involved in the whole process of implementation of e-LMS, starting from requirement phase through implementation. During e-readiness, requirement and analysis survey as it has been evaluated by Kalinga et al., [9]; questioners, physical observation and focus group discussion with students, teachers and school administrators were employed. The visualization was on the reasons for poor performance, problems facing the current status of education system and the needs towards the performance improvement. The survey was the starting point on introducing and creating awareness of the whole issue of development of e-LMS for Tanzanian secondary schools.

III. OBJECT ORIENTED SYSTEM ANALYSIS AND DESIGN

There are several approaches employed in system analysis and design. The most two commonly used approaches are: structured system analysis and design (SSA&D) and object oriented system analysis and design (OOSA&D).

Davis (1983) [6] and [10] discuss that structured analysis prescribes analyzing and designing software system through functional decomposition. It examines an Information System in terms of the functions it performs and the data it uses and maintains. SSA&D identifies the major functions or processes of a system, then breaks or decomposes each function down into its smaller composite steps [6] [10]. On the other-side OOSA&D decomposes the system down into objects and examines how these objects act and interrelate. The analyst first identifies the object that comprise the system, then create an object model which groups the objects into classes, and describes each class in terms of its attributes (or data), methods (or functions) and relationships to other classes [22].

OOSA&D approach will be employed in development of e-LMS. The main reason of this selection is that it employs UML as its documentation language. UML is also the one to be used in MDA. In software development successful information system are subject to frequent evaluation and revision within a framework known as System Development Life-Cycle (SDLC). The e-LMS is a system to be developed hence will abide to System Development Life Cycle (SDLC). SDLC for e-LMS will have:

- requirement and analysis phase where use-case and conceptual diagrams will be used

- design phase where sequence, collaboration, design class and component diagrams will be used
- implementation and testing phase where coding will be implemented

IV. Model Driven Architecture

The development of eLMS for Tanzania secondary schools will finally be implemented by customization of the selected open source LMS platform as per requirement and specifications of Tanzania environment. Selection of which open source platform to customize will be preceded with the creation of eLMS platform specific model. The reasons for choosing open source is discussed below, see section VI.

Object Management Group (OMG) is promoting model driven Architecture (MDA) as a way to develop systems that more accurately satisfy customer's needs and that offer more flexibility in system evolution (Brown, 2004) [2]. MDA improves requirement capture and system specification. Unified Modeling Language (UML) is one among the technologies specified by OMG as a language to enable model driven approach. OMG in its UML specification version 1.5 [16] defines UML as a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual modeling.

With the use of UML at its metamodel level, i.e. logical model level, several modeling graphics with different viewpoints will be created as a visual representation of the model. We found UML Modeling promote action research methodology by providing a basis for understanding the expected platform and promote a ready-to-use motion.

V. CIM, PIM, PSM and Transformation

MDA is a conceptual framework created by the OMG that separates business-oriented decisions from platform decisions to allow greater flexibility when architecting and evolving software development and deployment [2]. To support these principles, the OMG has defined a specific set of layers and transformation that provide a conceptual framework and vocabulary of MDA. These are Computation Independent Model (CIM), Platform Independent Model (PIM) and Platform Specific Model (PSM) [15] [2] [23] as shown in fig. 1. Along with conceptual framework, OMG through MDA also provides a set of standards to express models, model relationships and model-to-model transformations [2].

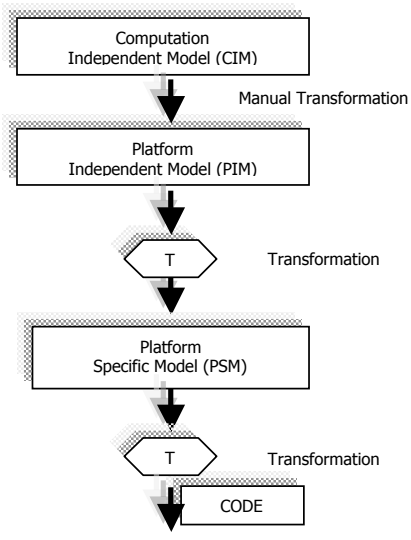

Fig. 1: MDA Framework

A. Computation Independent Model

CIM for e-LMS will be based on the requirements and specification of the early survey for e-readiness status [9] conducted for Tanzania secondary schools. UML will be used to model the user requirements and their boundaries. The e-LMS has considered several users including students/learners, teachers/instructors, authors, school administrators, system administrators and officials from the concerned Ministry, here Ministry of Education and Vocational Training (MoEVT). CIM also shows the e-LMS system architecture and standard specification to be employed.

B. Platform Independent Model

UML will model e-LMS at different viewpoint levels of abstractions from the platform independent viewpoint. This model will give what is being expected to be provided by e-LMS to Tanzania secondary schools. At this stage the structure of the e-LMS database through design class diagram can be used to select the open source LMS platform. The model of that platform will enable implementation of a system with desired qualities and will promote the nature of mapping towards PSM, which is in this case a web services platform.

C. Platform Specific Model

The e-LMS is a web based platform in order to carter for wide access to a big number of rural secondary schools in different regions of Tanzania. The functionality specified in the PIM is realized in a PSM through the application of some transformation. Web services applications is our target in this case which will run in an application server. Web services application is the nature of transformation from PIM to PSM. The transformation from PIM into PSM will be to express the UML into XML Metadata Interchange (XMI) using standard definitions expressed as XML Schema Definitions (XSD) as shown in fig. 2.

XMI is an application of Extensible Markup Language (XML), which lends itself to transporting information that is highly internally referential. XMI is applied to transport UML models by generating a special XSD through applying the rules of XMI to the concrete UML metamodel. The general mechanism applied within OMG to transport meta-information is XMI [17].

Finally, PSM will be mapped to application using interfaces, code and Structured Query Language (SQL queries) adapted from open source LMS platforms.

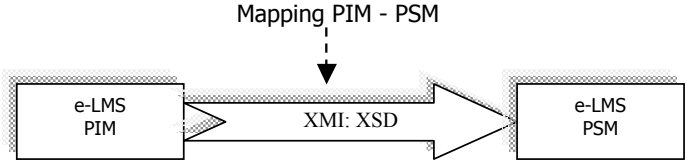

Fig. 2: PIM Transformation into PSM

Model transformation is the process of converting one model to another model within the same system. The PIM and other information are combined to produce a PSM. To perform this UML extension mechanisms are used to both PIM and PSM. UML are extended with UML profiles by adding semantics information to the models transformation [17].

We can relate the phases in OOSA&D with the conceptual framework created by OMG in MDA as shown in figure 3.

VI. Customization of Open Source LMS Platform

Learning Management Systems (LMS) are specialized Learning Technology Systems (LTS) [7] [8], based on the state-of-the-art Internet and WWW technologies in order to provide education and training

following the open and distance learning paradigm. Moore et al., [13] and Carlson, [3] argue that the design and implementation of such systems is not an easy task, since they are complex systems that incorporate a variety of organizational, administrative, instructional and technological components.

A Learning Management System is aimed at managing an e-learning environment, establishing the organization and delivery of content, administrating resources and tracking learning activities and results [5] [14]. LMS that are in use today are either commercial products (e.g. WebCT, Blackboard), or free open source products (e.g. moodle, claroline), or customized software systems that serve the instructional purposes of particular organizations. LMS that belong to the third category are exponentially increasing, as most education and training institutions are building or planning to build their own LMS. This is due to the fact that a customized LMS will fit better their specific learning purposes, and proves to give a good return of investment over the years [5].

It is obvious that Tanzania secondary schools can not afford the cost of commercial learning management systems like, as well as get hold of a system optionally fitted in the specific context. The alternative means is to customize and use open source LMS. To ease e-LMS development process and to help generate a timely solution, existing open source LMS codes will be re-used. Most open source LMS could support the basic functions we need in developing e-LMS, but there was an obvious need for detailed customization.

The drive of thinking on customization of open source platform is that open source software (OSS) is a software that is free in terms of its source code being available, as well as free in terms of purchase charges, and software licensing [18]. OSS source code is freely available to individuals to customize according to their own needs and distribute provided they abide by the accompanying license. This differs from commercial software which may only be obtained by some of payment; either by purchasing or by leasing. Open source software is based on open distribution of the source code that forms the software's foundations. This means that any technically competent programmer can examine the inner working of the source code, make changes to the operation of the software and contribute the source to others.

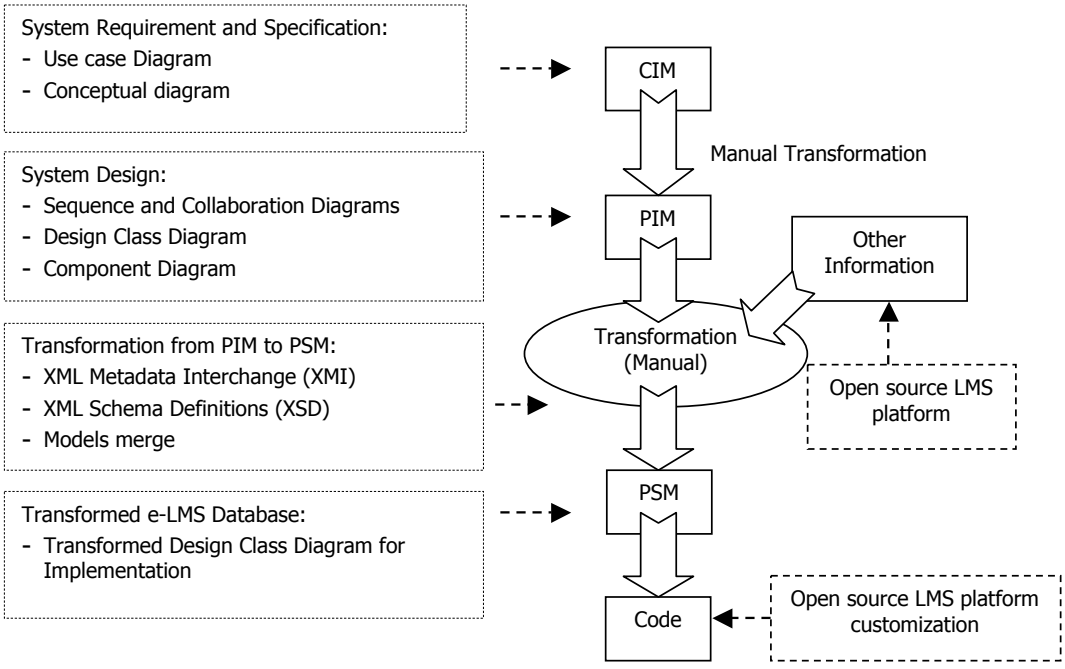

Fig. 3: OOSA&D Related to MDA Model-to-Model Transformation

VII. THE E-LMS DATABASE REPLICATION

The e-LMS database for Tanzanian secondary schools is intended to be centrally placed at the University of Dar-es-Salaam, College of Engineering and Technology. The idea of keeping the database centrally is mainly due to easiness of administration and maintenance of it by expertise. In reality majority of users of the e-LMS database are geographically dispersed and they rely on the Internet connectivity to access the database. The application response time and the availability of the database will be subjected to the condition of the Internet. Yair et al., [25] argue that the centralized approach suffers from two major drawbacks:

- Performance problems due to high server load or high communication latency for remote clients.
- Availability problems caused by server downtime or lack of connectivity. Clients in portions of the network that are temporarily disconnected from the server cannot be serviced.

Lack of connectivity due to several reasons like electrical power failure is the major problem in Tanzania. The server load and server downtime problems can be addressed by replicating the database servers to form a cluster of peer servers. There are many reasons why database replication is needed. Replication is generally for query load balancing, for disaster recovery (Restoration), for reducing latency, for bringing the data closer to the user, and for consolidating data from multiple sources. Because replication is based on the database logs it is very efficient in terms of performance compared with other methods of moving data [11]. Replication is an asynchronous, log-based process that permits copying of data from one location to another, keeping the data in the second location identical to the first [11].

Replication is a challenging issue since it involves much more than setup and there are not many sources of information for replication implementation and troubleshooting [19]. The challenge is on how to ensure database availability and meet end users needs. Fig. 4 shows the general replication outline.

VIII. CONCLUSION

Software design approach is applied simply to produce a software solution to a problem. To produce quality software we need to thorough understand the requirements that satisfy the user's needs. Visualization in the course of continuous improvement is a necessary basis for the participation of the personnel, and allows end-users to grasp the concept of operations of the system without having to understand software terminologies.

A model is used for understanding a system properly before its actual implementation. Integration of the power of models as emphasized by OMG with software development lifecycle stages promotes description of a system from different viewpoints, each focusing on particular concerns. A viewpoint, applied to a system, gives a view of that system. Customization of open source LMS platforms can be used to develop a system which is optionally fitted in the specific context.

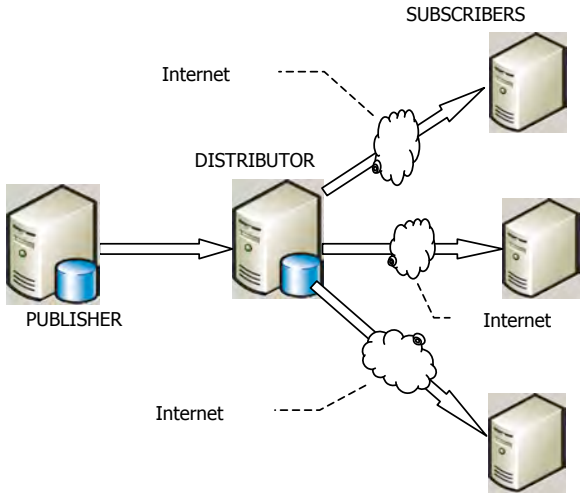

Fig. 4: Database Replication Outline

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ABSTRACT

e-learning, as defined to be the use of information and communications technology (ICT) for supporting the educational processes, has motivated Tanzania to apply ICT in its education system. Tanzania secondary schools in rural areas are geographically and socially isolated. Rural Tanzania secondary schools face a number of problems including ways in getting learning materials, as well as inadequacy of qualified teachers. The impact of these problems is poor performance in National Examinations. This poor performance however is highly noted in science and mathematics subjects. The problem in getting learning materials can be reduced by employing ICT in secondary school education system.

This research develops an interactive e-learning management system (e-LMS) to be used by Tanzanian secondary schools. The research is aiming to support teaching and learning functions by allowing creation and storage of learning materials, making them available, easily accessed and sharable among students from different secondary schools in Tanzania in a more organized way. Tanzania has only one curriculum for all secondary schools registered under the Ministry of Education and Vocational Training (MoEVT). During development stage it will not be easy to involve all scattered Tanzanian secondary schools. The research is focusing to two selected pilot schools; Kibaha secondary school and Wali-ul-Asr girl's seminary in Kibaha town, Pwani region. Features of the e-LMS will represent the standard form of any other secondary school registered by the MoEVT. The complete implementation of the e-LMS to these selected pilot schools will later be extended to all other secondary schools in Tanzania.

The development uses Object-Oriented System Analysis and Design (OOSAD) approach along with the power of modeling as it has been emphasized by Model Driven Architecture (MDA). Unified Modeling Language (UML) is mainly used in both cases. To create an interoperable system, UML is integrated with extensible markup language (XML) during model transformation from e-LMS Platform Independent Model (PIM) to e-LMS Platform Specific Model (PSM). Development will make use of open source software. For context specific development, participatory action research methodology is adopted and the inputs are well presented in developing e-LMS. Customization of open source learning management system (LMS) platforms is employed to help generate a timely solution to e-LMS development. Finally, this thesis also considers the need for replication and mirroring of the database for the purpose of making learning materials highly available to end-users.

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