Customization of Moodle Open Source LMS for Tanzania Secondary Schools' Use

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Abstract—Moodle is an open source learning management system that enables creation of a powerful and flexible learning environment. Many organizations, especially learning institutions have customized Moodle open source LMS for their own use. In general open source LMSs are of great interest due to many advantages they offer in terms of cost, usage and freedom to customize to fit a particular context. Tanzania Secondary School e-Learning (TanSSe-L) system is the learning management system for Tanzania secondary schools. TanSSe-L system was developed using a number of methods, one of them being customization of Moodle Open Source LMS. This paper presents few areas on the way Moodle OS LMS was customized to produce a functional TanSSe-L system fitted to the requirements and specifications of Tanzania secondary schools' context.

Keywords—LMS, Moodle, e-Learning, Tanzania, Secondary school.

I. INTRODUCTION

LEARNING MANAGEMENT SYSTEM (LMS) is the main element of the internet-based education. It is now common to find many educational organizations using LMS as one easy means of delivering learning material and managing learning process of learners. Reference [1] states that a learning management system (LMS) is a software system used to deliver on-line education. Today, most LMSs make extensive use of the Web and include features such as discussion forums, chats, journals, automated testing and grading tools and student tracking. LMSs are also used to supplement regular face-to-face courses. They are used in universities, schools and by businesses to deliver corporate training.

LMS which are in use today are commercial products, free open source products and/or customized open source (OS) LMS. The use of customized OS LMS is getting more popularity due to its flexibility in terms of cost, usage and freedom to customize to fit a particular context. 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 [13]. 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.

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TanSSe-L system development process had "Requirement Specification and analysis", "Design" and "Implementation" phases as per the object-oriented system analysis and design (OOSA&D) approach. The system implementation phase using the (OOSA&D) approach is the creation of code. Reference [11] states that database implementation includes coding and testing database processing programs, completing database documentation and training materials, installing the database and converting data if necessary from prior systems. At the end of system implementation, we expect to have a functioning system that meets the user's requirements as analyzed in earlier phases.

System implementation phase for TanSSe-L system involved customization of an open source LMS – Moodle, to create a functional TanSSe-L system as per Tanzania secondary schools' requirement and specification context. Before customization, the bases for customization was prepared where by the designed TanSSe-L system database structure in the form of a design class diagram (DCD) was compared with the selected Moodle open source LMS and highlight all necessary areas to be customized [10]. This paper presents few areas which were highlighted to be customized in Moodle OS LMS for TanSSe-L system use.

The rest of this paper is organized as follows: Section two provides a short literature review on open source software. Section three describes how Moodle was compared to TanSSe-L system database structure and ended up having a prepared guide for customization. Section four provides real customization to the selected areas to produce a functioning TanSSe-L system to be used by Tanzanian secondary schools. Section five describes the contribution made by this work. Finally this paper gives concluding remarks.

II. OPEN SOURCE SOFTWARE

A. Significance of 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 [13]. OSS code is freely available to individuals to customize according to their own needs and distribute provided they abide by the accompanying licence. This differs from commercial software which may only be obtained by some kind of payment, either by purchasing or leasing. OOS is based on open distribution of the source code that forms its foundation. This means that any technically competent programmer can examine the inner workings of the source code and make changes in the operation of the software. OOS is typically provided free of charge or for a nominal

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distribution cost. Some open source licences require that any change to the source code be redistributed on the same open source licence terms as the original source code [2], [4].

The benefits of OSS as published by [4] include:

- *Low initial cost:* it is free to download
- *Flexibility and customizability*: one can modify
- *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

B. Open Source Software Licensing

The primary underlying difference between the open source and commercial software is in the licensing of software. Commercial software providers typically adopt the traditional software licensing approach where permission to use the software is granted to a customer in return for a fee. The customer is usually permitted to use, reproduce or adapt the software only in accordance with the terms of the licence [5].

OOS is made available under a variety of licensing approaches with certain common features, such as the right to modify and the right to redistribute the software. The copyright within the software is the foundation of the licensing contract, as in the case of commercial software. Rights and permissions are granted subject to conditions. In general, these conditions restrict how the software may be further changed or distributed, rather than imposing a requirement that a fee be paid for it.

There are two principal open source licensing approaches [5]:

- *The GNU'S Not Unix General Public Licence*

Under the General Public Licence, all derivative works of the software and subsequent versions down the chain must be licensed and distributed on the same terms as the original software. Source code subject to the general public licence permanently remains subject to it. This permanent nature of the licence, as intended by its authors, constrains the options available to developers building on general public licence software in creating, distributing or commercializing products using its existing source code.

- *Berkeley Software Distribution Licence*

In contrast, under the Berkeley Software distribution Licence, developers have the freedom to integrate the licensed software with the developers' own source code to create new products with few restrictions. The Berkeley Software Development Licence, for example, allows programmers to use, modify and redistribute the source code and binaries of the original software. However, unlike the general public licence approach, programs containing code subject to the Berkeley Software Distribution Licence do not have to be distributed under that Licence.

From the same perspective, [6] explains that there are a number of open source licences, but they basically fall into two general categories:

- *Copyleft Licence*

Copyleft is a concept created by Richard Stallman. It is designed to be a pun on the word "copyright". Copyleft says that if you make changes to an open source program and distribute the resultant work, you have to make the source code of that new work available under the same licence so that others can share and similarly modify the software. The best example of a Copyleft licence is the General Public Licence.

- *Non-Copyleft*

In contrast to copyleft, software that is published under a non-copyleft open source licence has no such source redistribution requirements. This makes it possibility for OSS to be incorporated into proprietary software, subject to all the restrictions in a vendor's standard licence agreement. The best example of a non-copyleft licence is Berkeley Software Distribution.

This research used an open-source LMS for developing an interactive electronic learning management system (e-LMS) for Tanzanian secondary schools (TanSSe-L system). This approach is not new since open-source LMSes are widely used world-wide, such as Moodle, Sakai, Ilias, ATutor, ELedge, OpenUSS, LearnLoop and Claroline. Moodle, however, is the most popular of the bunch by far.

The main advantages of Moodle include reliability, robustness, security, extensibility, flexibility, great collaboration features, loads of free add-ons and plug-ins, regular releases (monthly), a large development team, and innovative, good support through the Moodle partners' network.

In contrast to Moodle LMS which is meant to be used by a single institution, TanSSe-L system has the strength as it is being intended to be used by a number of scattered Tanzania secondary schools.

III. TanSSe-L System Customization Guide

The approach taken to develop a Web-based TanSSe-L system was to design a database for TanSSe-L system while focusing the presence of a general open source LMS. The design used object oriented system analysis and design approach with UML to reach to a DCD for the TanSSe-L system [7]-[9]. As shown in Fig. 1, DCD is the real TanSSe-L system database structure for Tanzania secondary schools context which was related to Platform Independent Model (PIM) when referring to Model Driven Architecture (MDA) approach.

Design of TanSSe-L system's DCD took the approach in broader way following the standard way of designing LMSs. Reference [14] explains that 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

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users, learning materials (in the form of learning 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. With this focus brought forward by [14], with reference to Fig. 1, TanSSe-L system DCD had three major parts:

- Area showing the user identification information needed for TanSSe-L system – Area A
- Area showing the subject information (learning material) to be used in TanSSe-L system – Area B, and
- Area showing tracking events and reporting when a user visits areas of the TanSSe-L system – Area C

A. User Identification Information for TanSSe-L System

Reference [10] state that recording user information is the most important step since the development of systems needs to track how users utilize the system. Tracking reports will all include appropriate user identification information as per the specific domain in relation to different visits within the system. When looking into the information used to identify a user in Moodle, it can be seen that a lot of information is missing when compared to the TanSSe-L system user information. The missing information could easily be accommodated by either adding extra table/s for the missing information in Moodle or by adding extra fields within the table in Moodle (e.g. in mdl_user for user identification information) during the TanSSe-L system implementation stage. This is a kind of model merge approach used. On closer evaluation, the following extra information needed to be added to Moodle during TanSSe-L system implementation (Area A in Fig. 1):

- 'region' to get the name of the 'Region'
- 'district' to get the name of the 'District'
- 'schoolname' to get the 'School Name'
- 'gender' to get the user's 'gender'
- 'fomlevel' to get the 'Form Level'
- 'specialization' to get the subject area of specialization
- 'combination' to get subjects combination

B. Subject Information for TanSSe-L System

The main objective of the TanSSe-L system is to support Tanzanian secondary schools with teaching and learning functions. Though it can be seen that there is only one course table in Moodle (mdl_course), the final display of the course (hereby named subject in the TanSSe-L system) content looked similar to what was needed for TanSSe-L system. What was needed by the TanSSe-L system was to adopt the way Moodle handles subject learning materials with the slight alteration of having a 'Chapter Format' instead of a 'Topic Format' in Moodle.

C. Tracking Events and Reporting for TanSSe-L System

Tracking reports means tracking users' events when interacting with the system, hence reports involve describing the user who did that interaction. All Moodle tracking reports suit the TanSSe-L system's needed reports. Moodle reports needed to be modified to produce reports which identify the user as per the TanSSe-L system information as explained in sub-section 'A'. To have Moodle as the TanSSe-L system-specific PIM, all needed fields were included in SQL codes so as to add the required user information from mdl_user in tracking reports.

IV. Moodle OS LMS Customization for TanSSe-L System Use

Customization of Moodle OS LMS was planned to follow a sequence based on what should come first. This was easily reached with the help of the already prepared customization plan as briefly indicated in section two and at [10]. Following are key areas concentrated in customizing Moodle OS LMS for TanSSe-L system use:

A. Selection of Packages

The important and first thing to consider while thinking on customizing an open source is to get the appropriate package which will fulfill your requirements.

- "Moodle Package" with Concurrent Versioning System (CVS) Capability

There are a number of Moodle packages old and latest versions which are free to download and customize. When considering the issue of updating Moodle from version currently in use to upper versions, the first thing to think is to foresee the difficulties somebody may get in upgrading the customized Moodle package. Moodle with concurrent versioning system (CVS) capability would be the right option to download, install and customize. Reference [12] states that with CVS, all modifications done during customization will be tracked and stored. When Moodle is updated to higher version, CVS compares the two packages, merge them whenever possible and make the versioning update easier.

- "phpMyAdmin" Package

Reference [3] indicate that although the MySQL command-line clients offer an efficient, powerful means for working with the server, many users prefer the convenience of point-and-click interaction offered by graphical user interface (GUI) - based clients. Many such clients are available, several of which are available under open-source licensing arrangements. "phpMyAdmin" is an open source Web-based MySQL graphical user interface (GUI) client. PhpMyAdmin offers easy way of managing databases created in MySQL server such as: viewing data in tables, adding/deleting fields in database tables, managing database user privileges, passwords and resource usage, exporting (creation of database archives) and importing databases. This package was among the installed package to make easy management of TanSSe-L system database.
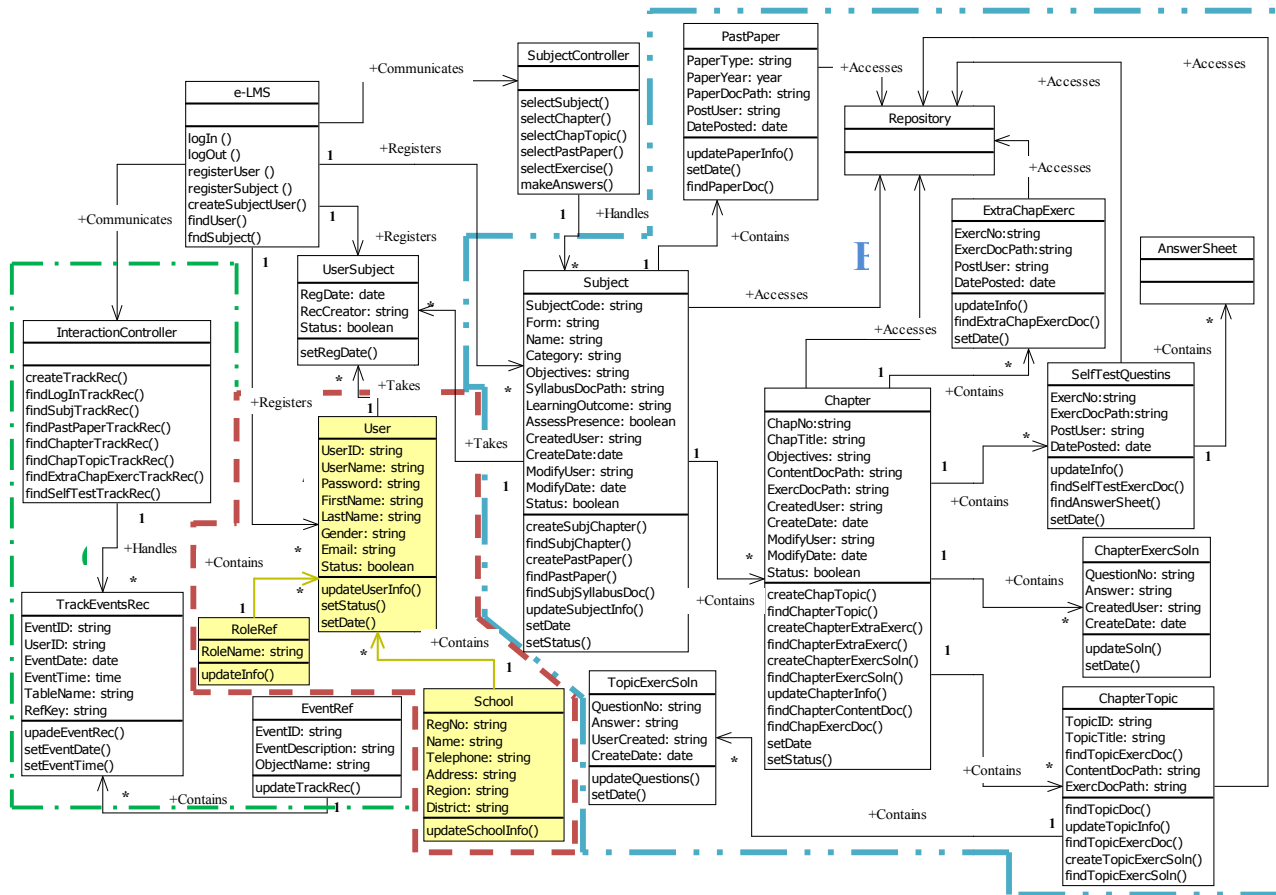
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Fig. 1 TanSSe-L System Design Class Diagram (DCD)
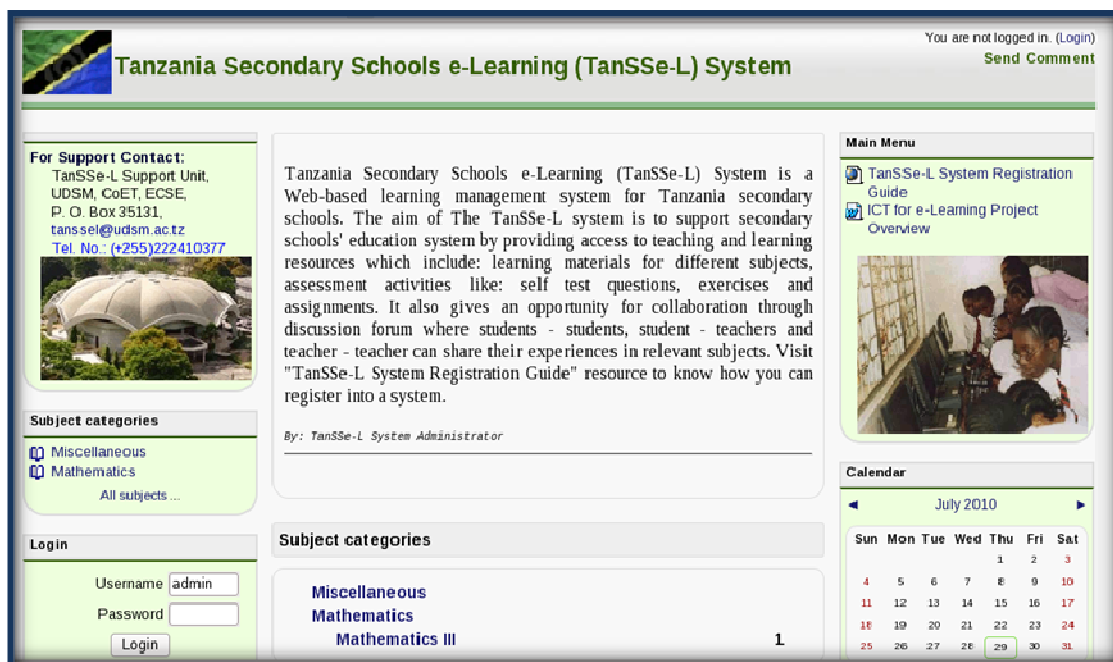
Fig. 2 TanSSe-L System Home Page

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B. Customization of TanSSe-L System Front Page

Moodle comes with a number of themes which are used in displaying the front page of the system. Standard theme was selected and customized with the new name, "tanssel" theme. This was done immediately after Moodle package installation so as to early start feeling the TanSSe-L system environment. Modifications included: header.php, footer.php and provided style sheet files. Fig. 2 shows the home page of TanSSe-L system.

C. Creating More User Information for TanSSe-L System

When comparing user information portion of TanSSe-L system design class and Moodle database structure, it was found that there were a number of information missing in mdl_user table of the Moodle database structure. To include this information, the followings were done [10]:

- *Addition of Required Fields for TanSSe-L System*

With the help of phpMyAdmin GUI MySQL client, required extra fields were added in mdl_user table. Fields added include: 'region', 'district', 'formlevel', 'schoolname', 'schoolregno' and 'gender'. However, some other Moodle fields were customized in language string to portray TanSSe-L terminologies. Fields like 'phone' and 'address' were made to read "School Phone No." and "School Address" respectively.

- *User Information Entry Interface Form*

Getting more user information for TanSSe-L system goes concurrently with the customization of user information data entry interface form. The customized entry form is as shown in Fig. 3. Added information includes all added fields into user table and simplifying data entry to some of these fields by making:
- ✓ "gender" to be selected either from 'Female' or 'Male'
- ✓ "region" to be selected from the already prepared list of Tanzanian regions
- ✓ "district" to be optionally selected from districts automatically displayed based on the region selected.
- ✓ "school name" to be optionally selected from the school names automatically displayed based on the district selected.
- ✓ "form level" to be selected from the prepared list of form levels
- ✓ "specialization" to be selected from the prepared list of subject specialization, e.g. science, art, agriculture etc
- ✓ "combination" to be optionally selected from the subject combinations automatically displayed based on the specialization selected.
- ✓ "country" to be by default 'Tanzania'

D. Dealing with Subject Information

Evaluation in the way Moodle OS LMS is dealing with a course seems to suite what is needed for the subject in TanSSe-L system. Small difference is in using terminologies like subject code in TanSSe-L system. Moodle LMS comes with a number of course formats, the display of a "topic format" is being adopted as it is, however the name was

changed and be "chapter format". What adopted is that each division in chapter format will display one chapter within a subject having all topic links and exercises of that chapter as shown in Fig. 4.

TanSSe-L subject is being identified using subject name and subject code. Language string for "shortname" has been customized to read "Subject Code". No default values are being set for both subject "Full Name" and "Subject Code", and they were both made required to force value entry.

- *Filtering of Subjects in Tracking Reports*

"Short Name" in Moodle is set locally to be unique for each subject full name apart from "id" field provided in mdl_course table in the database. This means that you can have more than one subject using the same full name but distinguished by a subject code as shown in Table I.

TABLE I
ONE SUBJECT NAME WITH DISTINCT SUBJECT CODE

Subject Full Name		Subject Code
Mathematics Form III	-	Math_III
Mathematics Form III	-	Math_IIIA
Mathematics Form III	-	Math_IIIB

With this arrangement, it is sometimes difficult to clearly identify which subject is being selected, especially in cases where the display shows only the list of subject by their full names without subject codes. The difficulty has been clearly noticed in tracking reports which provides either a selection of a subject name or a selection of a subject code and not both. Modification to this can be to include the display of a subject code whenever subject full name is displayed or to have locally set subject full name to be as well unique as shown below as an example. In view of this research, both approaches have been implemented, subject full names are being concatenated with their respective subject codes as shown in Fig. 5 as one example, and subject full name is also set locally to be unique as shown in Table II.

TABLE II
DISTINCT SUBJECT NAME WITH DISTINCT SUBJECT CODE

Subject Full Name		Subject Code
Mathematics Form III	-	Math_III
Mathematics Form IIIA	-	Math_IIIA
Mathematics Form IIIB	-	Math_IIIB

E. Customization of Tracking Reports

Evaluation and assessment on the usage of the TanSSe-L system rely fully on how the system will be able to provide relevant needed reports. Moodle comes with a good number of tracking reports which almost all suites the reports we need in TanSSe-l system. However, what lacks in these reports is extra information needed to identify users. Since TanSSe-L system is for Tanzanian secondary schools, it was needed to identify these targeted users' by the school name registered and/or the form level s/he resides for students, identification based on the Region and/or District the school is located, hence created the motivation of adding new fields in mdl_user table as shown in Fig. 6. The following have been done:

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Fig. 3 TanSSe-L User Data Entry Interface Form

Fig. 4 Chapter Format for TanSSe-L System Using Moodle

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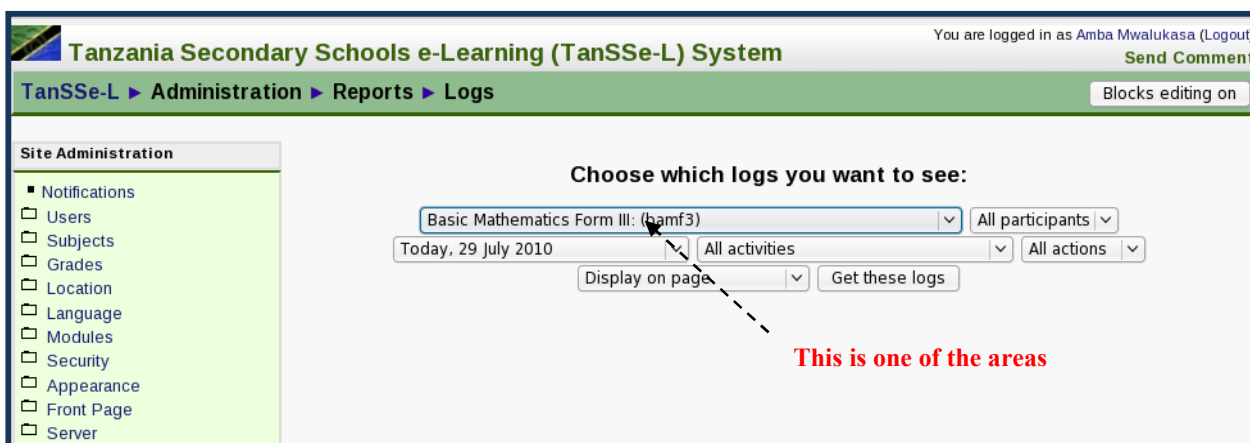
Fig. 5 Subject Full Name and Subject Code Concatenated
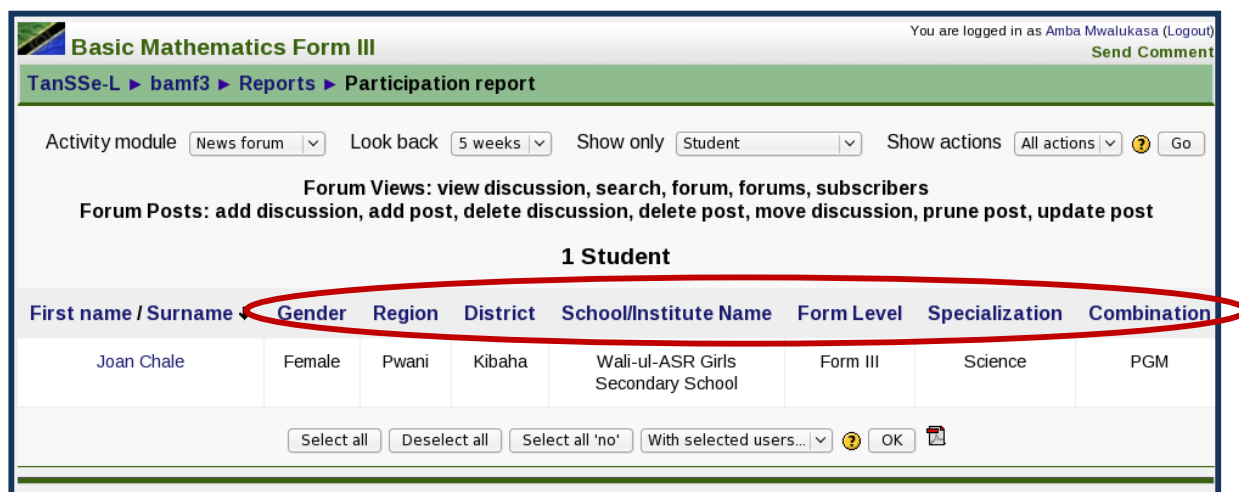
Fig. 6 Participation Report of Students to a Subject Activity

- In order to have information displayed from the database tables, required fields were added to MySQL database SQL query file codes so as to obtain needed information from database tables.
- Next was to go through all files which finally display these reports and add table fields and table data of the information we need about a user. These added fields involved all reports whether displayed within the system pages or exported in text and/or Excel formats. Fig. 5 shows one of the customized report "participation report of the students to a subject activity within TanSSe-L system with more needed information of 'Gender', 'Region', 'District', 'School/Institution Name' and 'Form Level'.
- Adding means of filtering user information based on new fields

It was also needed to evaluate users' participation in using TanSSe-L to be filtered in many ways. Added to filtering means provided by Moodle, now it is possible to filter bulk of uses based on the added fields as shown in Fig. 7, for-example based on form level for students, or it can be a combination of more than one filters.

F. New Added Reports for TanSSe-L System

When looking to other important areas which we need to track events, the following two new reports were added to TanSSe-L system:

- Tracking Access to Resources Provided in TanSSe-L Home Page

This report is in site administration block intending to track a number of visitors of the TanSSe-L home page who will access free resources provided within the home page of the system. The report has been adopted from "outline" report within a subject. It will count number of visits performed by anyone to each resource provided in TanSSe-L home page even before login.

- "coursesize" Module for Administrative Report

Course size report is an open source report module downloaded from moodle.org site. Course size report is an excellent work contributed by *Shane Elliott* into Moodle community. Course size report displays a list of all subjects created in TanSSe-L system together with associated disk usage from the data directory as shown in Fig. 8. Size can be

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filtered in GB, MB, KB and Bytes. This report will help in knowing the memory capacity usage of each subject in TanSSe-L data directory and in its totality. It will also help to show the list of subjects and the total number of subjects in TanSSe-L system, the part which was added.

- TanSSe-L System Reports in PDF Format

To make TanSSe-L reports friendlier in terms of downloading, many reports have been converted into portable document file (pdf). Fig. 9 shows a users' participation report presented in pdf format for a specific selected activity module done by a student.

G. Customization of Language Strings

There are many different terminologies used in TanSSe-l system but are not present in Moodle. Moodle has a "lang" directory with a number of files each having a list of strings which are used to convert table field names and other strings to have a meaningful language display in Moodle web pages. Customization of language for TanSSe-L system can be divided into two groups:

- Adding string definition of all new word names introduced in Moodle tables e.g. mdl_user table and in Moodle directory files, e.g. $string['region'] = 'Region';
- Customization of strings found in Moodle to suite our TanSSe-L system terminologies. These were done through site administration block, and the edited strings were stored in local "lang" directory, e.g. $string['course'] = 'Subject';

Language customization covered also help files within the TanSSe-L system. Customization for the existing string was done through "Site Administration >> Language >> Language editing".

Fig. 7 User Information Filtering Fields

Fig. 8 List of TanSSe-L System Subjects with Respective Disc Sizes

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Fig. 9 Participation Report in PDF Format

H. TanSSe-L System User Roles

Moodle comes with a number of all possible capabilities which can be performed within the system. What is required is to select capabilities and grant permissions to those selected capabilities to a role. It is important to thoroughly study the default user roles and their permissions set which comes with Moodle and see if they suite TanSSe-L system. All of the default user roles were adopted, but some needed modification in setting permissions to suite our roles. These roles include: 'Administrator', 'Subject Creator', 'Teacher – (editing teacher)', 'Non-Editing Teacher', 'Student', 'Guest' and 'Authenticated user'.

For TanSSe-L system, there are more user roles which were needed to be created and set permissions accordingly. The new user roles created include: 'School Administrator', 'Educational Observer' and 'Content Administrator'. Creation of TanSSe-L system user roles were done by the help of guide from [12] Web site. Moodle.org shows the possible locations for assigning roles based on context. Context provided and based on TanSSe-L system terminologies are: system, front page, subject category, subject, module, block, and user.

I. Other Customized Areas

HTML editor with mathematical expression

"DragMath" is an open source drag and drop equation editor. It is a tremendous work contributed by *Marc Grober*. This package was downloaded, installed and integrated into TanSSe-L system's HTML editor provided within the system. The package can be used to create simple mathematical expressions like $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ whenever needed. Using DragMath, mathematical expression can be written in normal way and DragMath converts it into a variety of different linear syntax for mathematics which includes: MathML, LaTex, Maple, Maxima or any user defined style (moodle.org, 2009) [11]. Fig. 10 shows the DragMath equation editor with mathematical expression ready to be inserted into HTML editor.

J. Development of TanSSe-L System User Guide

TanSSe-L system user guide was among obligations to be accomplished during implementation stage. User guides for different roles were created and made available for all registered users. For easy access, a link was provided to call all user guide resources after successful login to the system as shown in Fig. 11, and it was provided at home page such that new users can easily view the link.
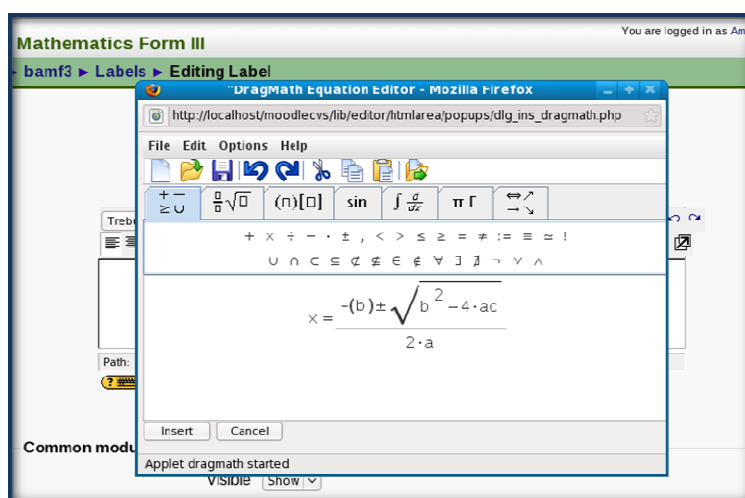

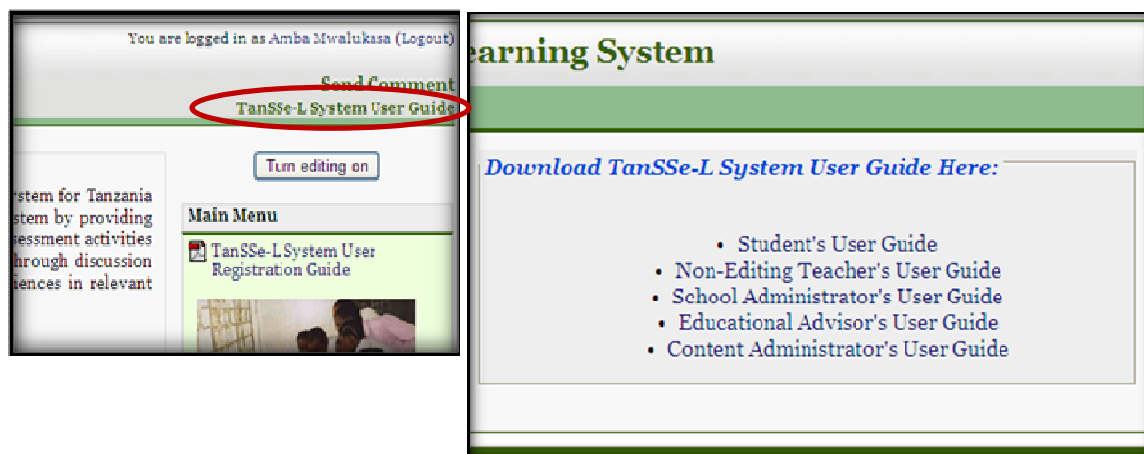Fig. 10 DragMath Equation Editor with Mathematical Expression

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Fig. 11 TanSSe-L System User Guide

V. STUDY CONTRIBUTION

The TanSSe-L system is a special donation to Tanzania Secondary Schools. It is the first one to be introduced and developed so far. The TanSSe-L system is a quality product engineered in Tanzanian secondary schools environment. Tanzania secondary school stakeholders are free to keep e-learning materials and make them accessible to many students. TanSSe-L system is accessible using http://tanssel.ecse.udsm.ac.tz/moodlecvsurl, currently hosted at the University Computing Center of the University of Dar-as-Salaam.

VI. CONCLUSION

Tanzania being a developing country cannot afford the cost of commercial learning management systems, as well as get hold of a system optionally fitted in the TanSSe-L system specific context. It is wise to effectively use the advantaged opportunities brought forward by open source community. There is a possibility of creating something concrete using open source software. Most open source LMS could support the basic functions we need in developing TanSSe-L system, however there was an obvious need for detailed customization.

Customization is done as per organization context. A thorough study has to be implemented in order to identify needs for the system. TanSSe-L system PIM in the form of a design class diagram (DCD) was fully designed using software engineering discipline. Object oriented system analysis and design using UML was used together with Model Driven Architecture (MDA) to get a well-defined software development process up to customization stage.

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