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Learning Design Map (LDMap) for Mathematics Teachers in Developing Countries and the Benefit of Its Use for Curriculum Review

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Abstract

In this paper, Learning Design Map (LDMap) to document and share mathematical teaching and learning experiences are proposed. These maps are intended for use by mathematics teachers in developing countries. The development of the maps is based on a survey that gathered information related to the real and perceived ICT infrastructure, facilities, and resources, in one accessible area in a developing country. These maps can be created by teachers. It is expected that the map will be shared and modified by teachers and that there will be a circulation of the mathematical teaching and learning experiences among teachers through the use of these maps. The Learning Design Map (LDMap) is based on XML technology so that the data contained in this file can be extracted across platforms. Through mapping assessments, outcomes, resources and other attributes as considered desireable in the LDMaps can be designed to facilitate curriculum review. The benefit of the use of LDMaps for curriculum review is explored.

1. Introduction

Technology is one aspect in human civilization that spreads quickly from one nation to other nations. The spreads of technology, especially information and communication technology, has influenced and changed human life. In the field of education, technology has been adopted not only in universities but also in secondary and primary schools. Because of advantages that make the process of teaching and learning more effective and efficient teaching with technologies has occurred in many places. The fundamental or core nature of mathematics, its compulsory acquisition, requires a high quality of mathematics learning experiences, not only in elementary schools, but also in secondary and tertiary levels. It is highly desirable that the emergence of new technology positively influences learning experiences in mathematics [1].

In order to facilitate the sharing of a high quality and technology-supported learning experiences, learning designs representations have been created. According to [2] six learning design representations have emerged. They are Educational Environment Modeling Language (E2ML), IMS Learning Design (IMS LD), Learning Activity Management System (LAMS), Learning Design Visual Sequence (LDVS), Software LDLite, and Software Patterns.

A comparison of these learning design representations [2], reveals that most of them deal with online activities or are implemented on online platforms. For high technology countries like US, UK, Japan, or Australia it is relative easy to implement these because internet access is readily available to support online platforms or activities. However for some developing countries such as Indonesia or Nigeria, it is problematic because internet access in these countries is poor.

According to the IMF [4], there are 34 countries in advanced economies and around 150 emerging and developing countries.

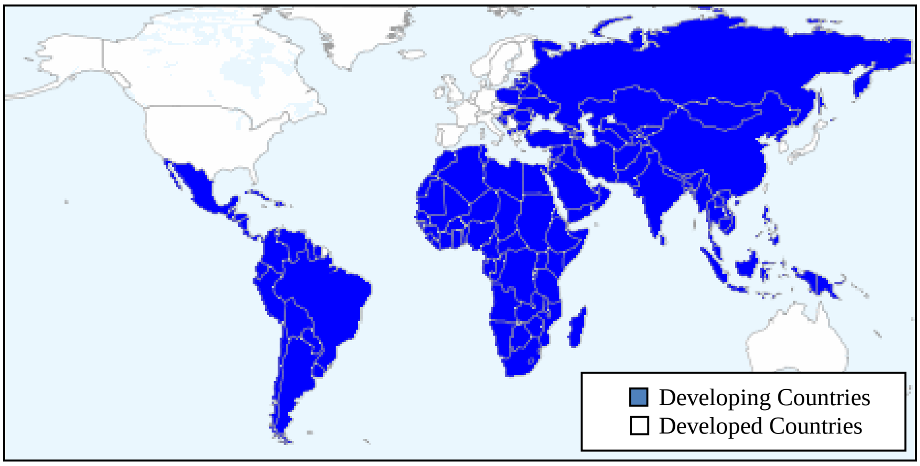

Figure 1: Distribution of developing countries in the world [4]

This data shows that 81.5 % of countries in the world are developing countries. To help close the gap, it is important to share expertise and this can happen through the sharing of learning designs representations that can be implemented in developing countries.

2. Study and Findings

The implementation of technology-based learning in mathematics requires supporting infrastructure, facilities, and resources and thus need to be identified when planning use technology. These terms are defined by Oxford Dictionaries [5] as follows: “Infrastructure is defined as the basic physical and organizational structures and facilities needed for the operation of a society or enterprise”, “facility is defined as a place, amenity, or piece of equipment provided for a particular purpose”, while “resource is defined as a stock or supply of money, materials, staff, and other assets that can be drawn on by a person or organization in order to function effectively”.

These three terms define what needs to be known in order to implement technology-based learning. With regard to infrastructure for technology use, the context and ICT infrastructure in the area, the schools, and teachers’ home need to be known. Facilities for teaching include the computer lab, computers, printers, scanners, internet connections, hand phones, and the level of expertise to use and service them. Effective use of these facilities also relates to access to resources such as digital materials, CDs, DVDs, and software or more generally support for teachers to teach different topics in different discipline areas.

A survey in one accessible area of developing countries, Bojonegara Sub District, Indonesia was conducted in October 2010 to February 2011. According to [3] several important findings about ICT infrastructure, facilities, and resources in this area were gathered. For example:

> It is now known that computer laboratory and internet access are only available in junior and senior secondary schools. Most of the teachers access and use the internet to gather educational content for use in teaching and learning...
>
> It is suggested that the Teachers-Centered Learning with Technology is the most appropriate method of technology-based learning to be implemented in Bojonegara Sub District, Banten Province Indonesia [3]

According to [6] there are five technology-based learning methods available. These methods derived based on the concept of learner control.

Table 1: Matrix of Technology-Based Learning Methods

Technology-Based Learning Methods			
Learning Method	**Center of Control**	**World of Work Example**	**Strategies**
Teacher-centered learning with technology	Teachers: The teachers directs the pace and sequence	Training sessions, specific skill development	Multimedia presentation, videotape, distance instruction
Integrated learning system	Machine: A computer network and its software direct the learning	Teaching machines	Distributed ILS, lab-centered ILS
Electronic collaboration learning	Teams or partners: The teams negotiates, goals, pacing, and sequence of learning	Developmental teams, joint research efforts, learning teams	Local area networks, wide area networks, cooperative ventures
Hyperlearning	Learner: The learner is in charge of pace and sequence of learning	Research, market analysis, engineering design	Hypertext development, hypermedia development, multimedia development, network searching
Electronic learning simulations	Machine and learner: Learning is in joint control	Flight simulators, disaster control simulations, war games	Virtual electronic simulation

Source: Adopted from Ross (1995) Learning Methods Matrix

In Bojonegara Sub District, where the data was collected, teachers are willing share their mathematical teaching and learning experiences, learning designs, with other teachers but currently do not usually share the typically paper based learning resources [1]. Based on these survey results and discussion, it was deemed possible and important to provide appropiate technology supports for teachers to prepare and share their learning designs. One possible support, related to learning designs, and this was the development of maps that can be used to document and share identified mathematics teaching and learning experiences. This mechanism can support teachers who in this educational system operate within the technology model in teacher-centered mode.

The map of learning designs is in electronic format as illustrated in Figure 2

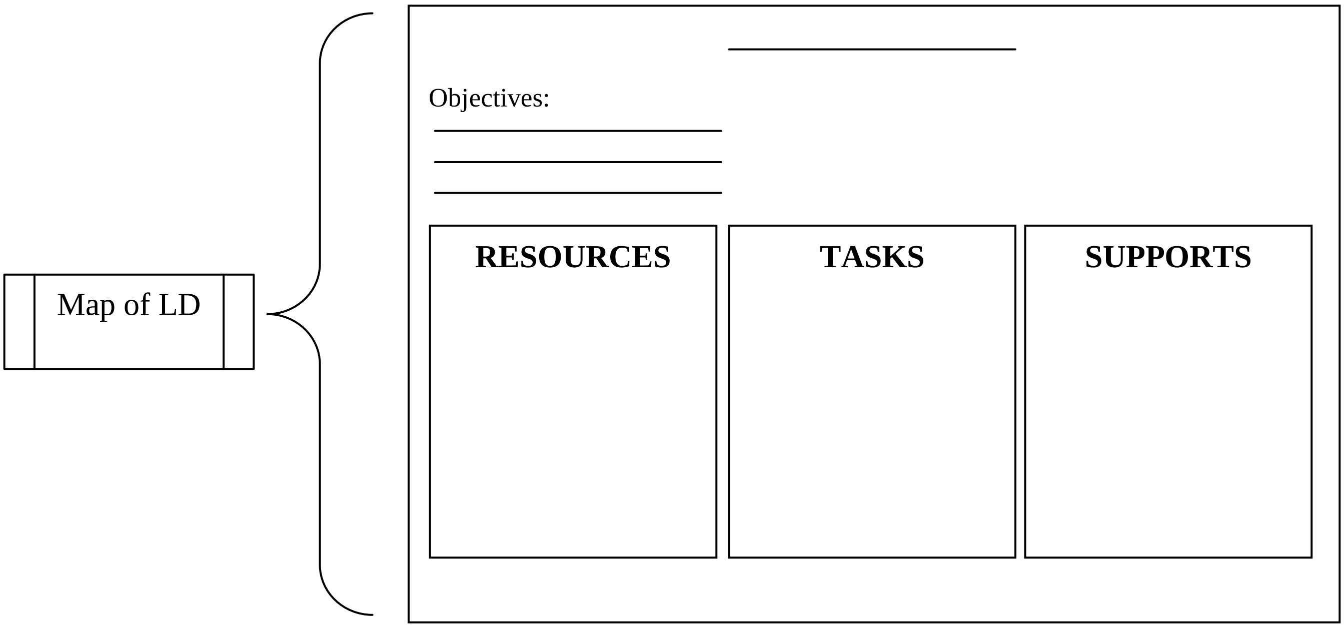

Figure 2: A Concept of Map of Learning Design

It was anticipated that the map could be created and modified by one or more teachers and shared with others creating a circulation of maps and through this the sharing of mathematical learning experiences of teachers. More formally it can be used by curriculum developers to provide support for teachers by providing them the expected design of learning. This approach may be related to the direct instruction program that describes the step by step actions to achieve the effective and efficient way to meet the standard and principles of teaching and learning. As explained in [9], 12 studies related to direct instruction program were reviewed, and 7 of 12 studies showed positive results. However the mapping through the proposed map is different from the direct instruction mathematics program because it is providing the mapping of resources, tasks, and supports for teachers whereas the direct instruction program does not cover it.

The proposed map is based on two current and available ICT Technologies, these are XML (eXtensible Markup Language) and Microsoft Visual Basic. XML has an advantage managing data, in this case it is the content supplied to the learning design map by teachers or curriculum designers. It is also possible to make the learning designs map and the learning design data contained in this map available across platform, not only in the Windows Platform, but also in Mac and Internet Platforms. Visual Basic has been used to develop a windows-based application to read the map.

The learning design maps, called LDMap, can be read by an software associate reader, called LDSoft, which is specially provided to work with these maps. The software associate reader is designed using Visual Basic. The development was based on Microsoft Windows platform and took advantage of the spread of internet technology, because these technologies are well accepted and widely used in developing countries [3]

Following is the design of XML file as the map of learning design

```
<?xml version="1.0"?>
<LDSoft>
  <Session>
    <Title> </Title>
    <Duration> </Duration>
    <Minor_Assignments> </Minor_Assignments>
    <Main_Resources> </Main_Resources>
    <Competency> </Competency>
    <Supporting_Resources> </Supporting_Resources>
    <Additional_Resources> </Additional_Resources>
    <Additional_Assignments> </Additional_Assignments>
    <Major_Assignments> </Major_Assignments>
    <Other> </Other>
    <Consultation> </Consultation>
    <Lab> </Lab>
  </Session>
</LDSoft>
```

Figure 3: The Design of XML File as a Map of Learning Design

Each node (Title, Duration, ..., Lab) are components of the map and serve as placeholder for the content.

The Use of the Maps

Collaborative research with mathematics teachers in Bojonegara Sub District, Indonesia provided a means of trialling the electronic maps. The teachers were selected from a group of teachers who participated in an earlier survey investigating situation of infrastructure, facilities, and resources available for teachers and students.

In the implementation phase of investigation, to facilitate comparisons between school levels, a total of 12 mathematics teachers, four mathematics teachers from each level (elementary, junior high school, and senior high school) were expected to participate. Researchers also considered teacher ICT skills and their school ICT facility in choosing the teachers to include. However, in practice, more than four mathematics teachers from elementary school level wanted to participate, so the researcher allowed six of them to be participants in collaborative research. One mathematics teacher participant from senior secondary school resigned due to illness, so the number of mathematics teacher participants from senior secondary school felt to three.

Following is the detail of the participants of the implementation phase

Table 2: Participants identity based on school level

		Frequency	Percent	Cumulative Percent
Valid	Elementary School	6	46.2	46.2
	Junior High School	4	30.8	76.9
	Senior High School	3	23.1	100.0
	Total	13	100.0	

The number of teachers as participant in the collaborative research is not exactly the same as sought through sample estimation, with less than in the senior secondary and more in the elementary school level. However these were considered viable number in terms of completing the project and representing different infrastructure available in the schools.

The collaborative research evaluating the use of electronic maps (LDMap) and its software associate reader (LDSoft) by mathematics teachers was implemented between January to March 2012 with 13 mathematics teachers in Bojonegara Sub District, Indonesia.

Table 3 displayed the distribution of participants' teaching duty.

Table 3: Distribution of Participants' Teaching Duty

		Frequency	Percent	School Level
Valid	Grade II	1	7.7	Elementary School
	Grade V	2	15.4	
	Grade VI	3	23.1	
	Grade VII	1	7.7	Junior Secondary School
	Grade VIII	2	15.4	
	Grade IX	1	7.7	
	Grade XI	1	7.7	Senior Secondary School
	Grade XII	2	15.4	
	Total	13	100.0	

In Indonesia, the Elementary School Level ranges from Grade I to Grade VI, Junior Secondary School Level ranges from Grade VII to Grade IX, and Senior Secondary School Level ranges from Grade X to Grade XII. Before the school level, there is a pre-school level (play school and kindergarten), and after the school level there is a tertiary (university) level.

According to Table 3, three (23.1%) of participants are teaching mathematics in Grade VI (elementary school level), followed by two (15.4%) participants from Grade V, Grade VIII, and Grade XII, and one (7.7%) participant from Grade II, Grade VII, Grade IX, and Grade XI . Participated mathematics teachers represented 8 (66.7%) available grades in school levels.

For each teacher, general information (gender, grade of teaching class, ownership and type of computers to be use in school and home) was collected together with their satisfaction with components of the electronic map of the learning design. Refer to Table 4 for a list of components tested.

Table 4: Satisfaction and Evaluation Components of Electronic Maps

Satisfaction Components

Electronic Maps	**The Software associate reader of Electronic Maps**
1. Idea	1. Idea
2. File Structure	2. Layout of Software
3. Characteristics	3. Characteristics
a. Creating Curriculum-aligned and non Curriculum-aligned Learning Designs	a. Connection to Electronic Maps
b. Convert able to HTML	b. Using XML Technologies
c. Modifiable and Shareable ability	c. Record Learning Designs for Each Session
4. Function	4. Function
5. Innovation	5. Innovation
6. Implementation	6. Implementation

Teachers evaluated the prototype LDMaps using a questionnaire and through discussions with the researcher. Several instruments were used to gather this information, including a questionnaires package, guidelines for interviews, and a video recorder for documentation (photos and videos).

Table 5 summarised the mathematics teachers' satisfaction with components of the electronic maps of learning designs (LDMap).

Table 5: Teachers' Satisfaction of Electronic Maps of Learning Designs

No	Components	Satisfaction							
		Very Satisfied		Satisfied		Somewhat Satisfied		Not Satisfied	
		Count	%	Count	%	Count	%	Count	%
1	Idea	11	84.6	2	15.4	0	0.0	0	0.0
2	File Structure	7	53.8	6	46.2	0	0.0	0	0.0
3	Characteristics								
	a. Creating Curriculum-aligned and non Curriculum-aligned Learning Designs	6	46.2	6	46.2	1	7.7	0	0.0
	b. Convert able to HTML	8	61.5	5	38.5	0	0.0	0	0.0
	c. Modifiable and Shareable ability	5	38.5	8	61.5	0	0.0	0	0.0
4	Function	7	53.8	6	46.2	0	0.0	0	0.0
5	Innovation	9	69.2	4	30.8	0	0.0	0	0.0
6	Implementation	4	30.8	9	69.2	0	0.0	0	0.0

Derived from this table, as illustrated in Figure 4, components for which the mathematics teachers are very satisfied include the idea and innovation, although there is more scope with later prototype to improve usability.

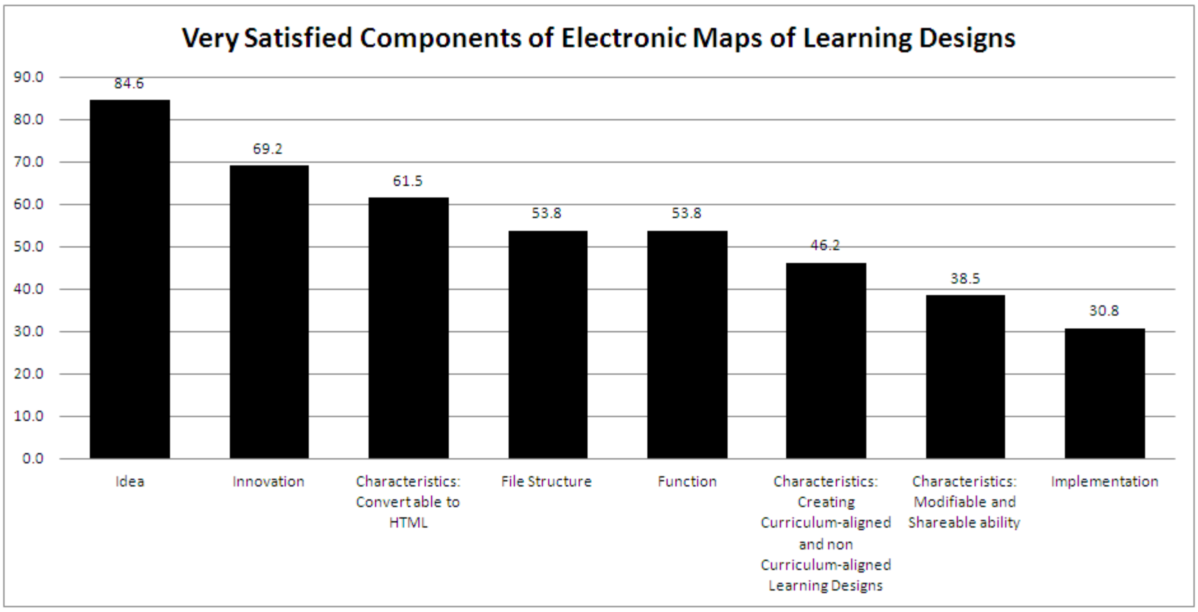

Figure 4: Very Satisfied Components of Software associate reader of Electronic Maps

A summary of satisfaction with components of the software associate reader of the electronic maps (LDSoft) is provided in Table 6. According to the Figure 5, components in which mathematics teachers are very satisfied with the software associate reader include idea, innovation and characteristic of the software associate reader that is how this software associate reader connects to electronic maps. Again further work is needed to better implement the maps.

Table 6: Teachers' Satisfaction of software associate reader of Electronic Maps of Learning Designs

No	**Components**	**Satisfaction**							
		Very Satisfied		Satisfied		Somewhat Satisfied		Not Satisfied	
		Count	%	Count	%	Count	%	Count	%
1	Idea	10	76.9	3	23.1	0	0.0	0	0.0
2	Layout of Software	5	38.5	8	61.5	0	0.0	0	0.0
3	Characteristics								
	a. Connection to Electronic Maps	7	53.8	6	46.2	0	0.0	0	0.0
	b. Using XML Technologies	6	46.2	7	53.8	0	0.0	0	0.0
	c. Record Learning Designs for Each Session	5	38.5	8	61.5	0	0.0	0	0.0
4	Function	7	53.8	6	46.2	0	0.0	0	0.0
5	Innovation	8	61.5	5	38.5	0	0.0	0	0.0
6	Implementation	2	15.4	11	84.6	0	0.0	0	0.0

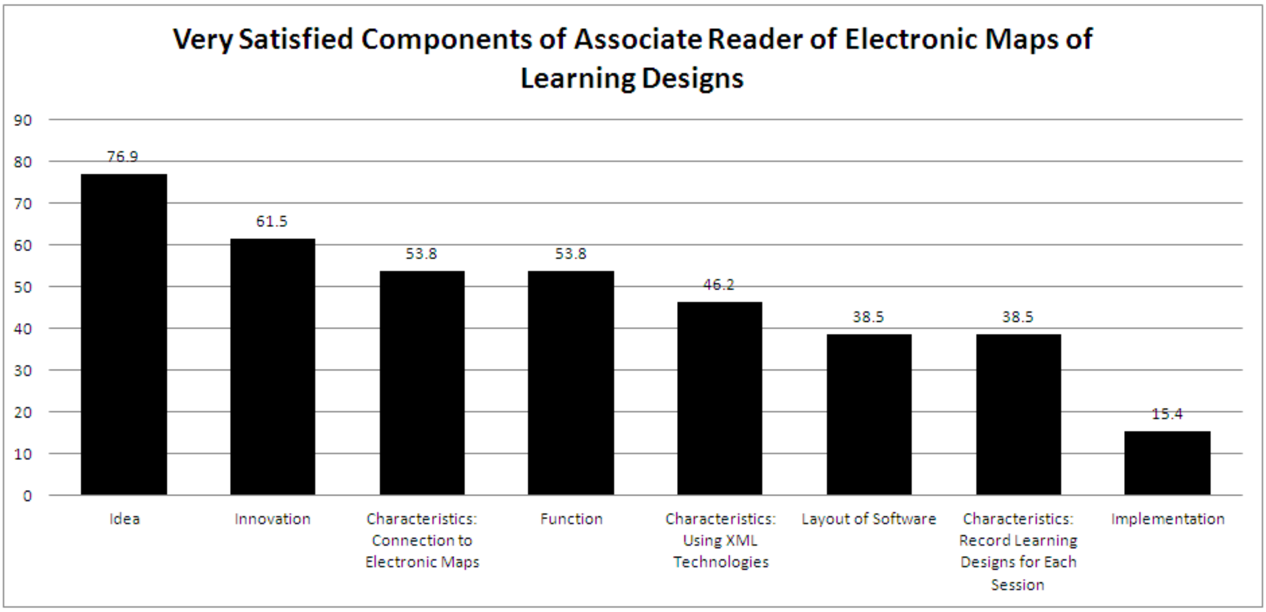

Figure 5: Very Satisfied Components of Software associate reader of Electronic Maps

3. The Use of LDMap for Curriculum Review

LDMap is an electronic map with file type eXtensible Markup Language (XML) with file extension *.xml. This XML file contains data regarding the learning design created by mathematics educator. The data can be extracted across operating system platform and internet using many software and which are able to extract data from XML files.

One such piece of software capable of extracting data from LDMap is Microsoft Office. According to [7] the XML capabilities in Microsoft Office bring the following benefit: 1) Information capture and reuse; 2) End-user data connection, and 3) Data-driven application enhancement. Based on these benefits, the learning design data in LDMap can be captured and reused, connected to other application, and able to enhance the applications related to the use of learning design data. One of proposed use with this data involves review of mathematics curriculum based on LDMap data.

Assuming that the LDMap is implemented by mathematics educators in a school or department of mathematics to document their learning designs then there will be available several LDMap files in the school or department, in which each LDMap is associated with one subject as illustrated in Figure 6.

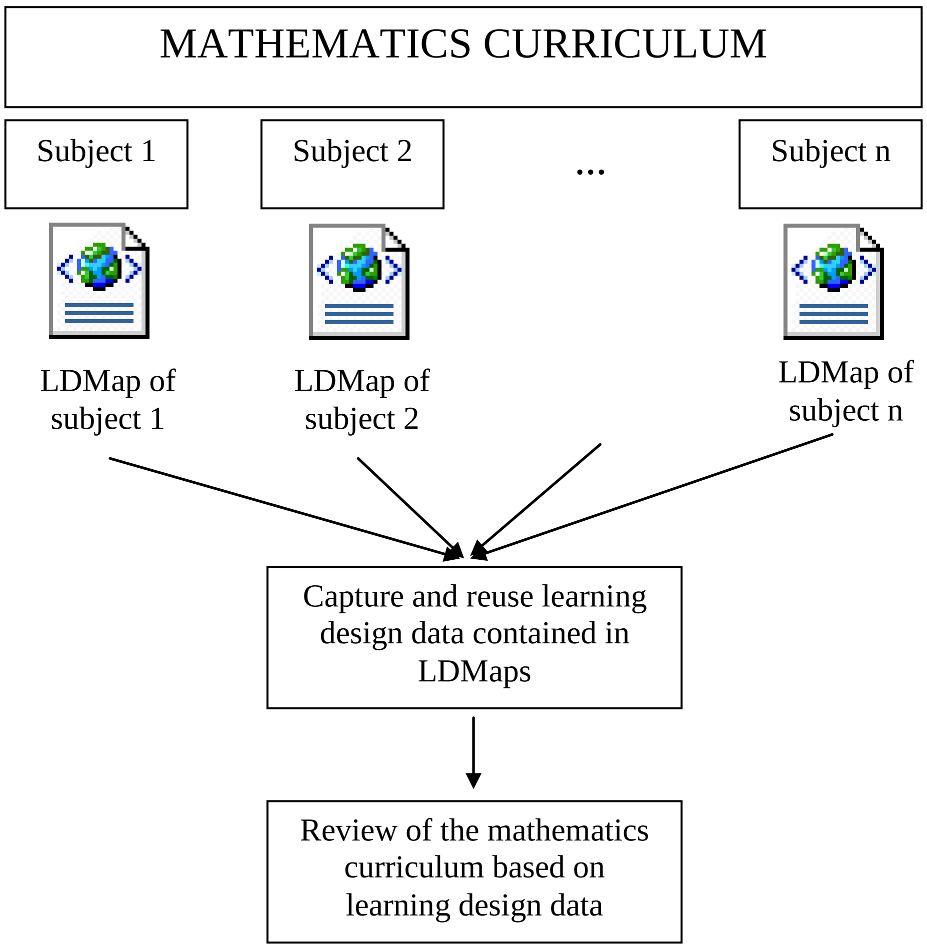

Figure 6: Concept of the Use of LDMap in Curriculum Review

A tool developed to extract learning design data from LDMap is based on Microsoft Excel. It would also be entirely feasible to automate the process of producing student information sheets. This tool can be use to import the data from all subjects LDMaps to a spreadsheet to be analysed. The analysis can be done automatically after all data from LDMaps are successfully imported.

Following is the step by step or scenario of the use of LDMap for curriculum review. Two selected mathematics subjects, Discrete Mathematics (MATH121) and Mathematics for Primary Educator (MATH131) were selected as the example for this purpose.

1. Open the curriculum reviewer (Microsoft Excel based tool)

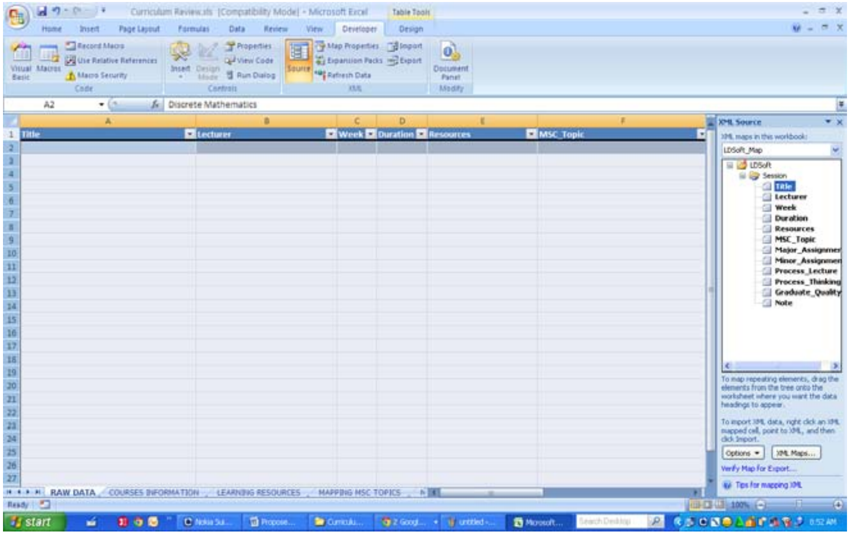

Figure 7: Curriculum Reviewer

2. Click import in the Developer Tab, then select all LDMaps to be imported by Excel

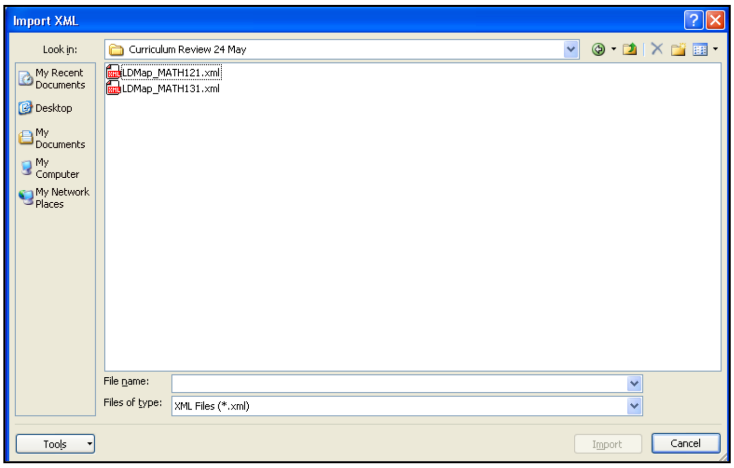

Figure 8: Process to Import All LDMap files to Curriculum Reviewer

3. The data from all LDMaps will be inserted in Raw Data worksheet.

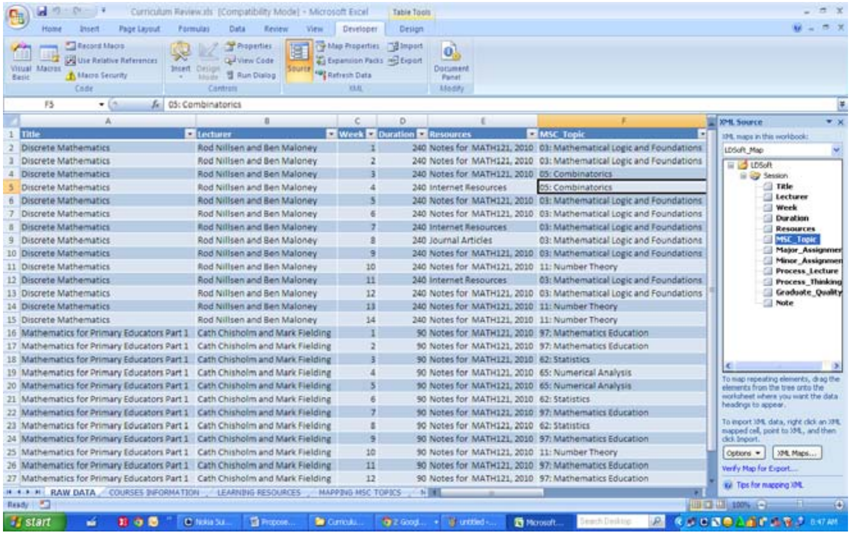

Figure 9: Imported Data from LDMap Files

4. Then the data will be automatically analyzed by the spreadsheet. Currently in accord with the LDMaps five information are available as a result of the review which can be used by the school or department as a source of self reflection, evaluation, or information provision for say accreditation.

    1) Subject Information
    This section displays a list of subjects and the expected process of teaching and learning (lecture, discussion, etc) of each subject for all subjects provided by curriculum.

    2) Learning Resource
    This section displays a list of the type of learning resources available and expected to be used by lecturer or teacher for all subjects provided by curriculum.

    3) Distribution of Mathematics Subject Classification
    This section displays distribution of mathematical subjects' classification of subjects provided by the curriculum. This is a unique feature of mathematics in which mathematically-related literature can be indexed based on this classification. Mathematics Subject Classification is produced by editorial staffs of Mathematical Reviews and Zentralblatt fur Mathematik (Zbl) in consultation with mathematical community [8]. This information also reflects the school or department strength, for example a higher percentage of subjects or most of teachers or lecturers are in the field of Geometry, Algebra or others fields.

    4) Distribution of Graduate Qualities
    This section displays distribution of graduate qualities expected to be achieved by the implementation of curriculum.

    5) Evaluation.
    This section displays types of evaluation undertaken or scheduled to be held by lecturers or teachers for each subject.

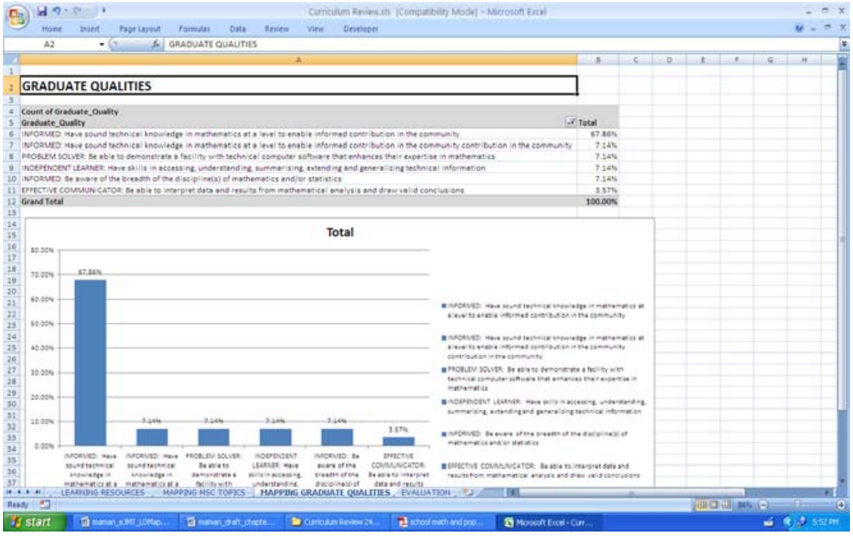

Figure 10: Mathematics Curriculum Review with Regard to Graduate Qualities

For example, given the two subjects Discrete Mathematics (MATH121) and Mathematics for Primary Educator (MATH131), the results of curriculum review as displayed in Figure 10 reveals that in the Section “Graduate Qualities”, the item “Informed: Have sound technical knowledge in mathematics at a level to enable informed contribution in the community” is counted at 67.86% of total expected graduate qualities to be achieved through the implementation of current curriculum. It is means that for these two example subjects, this graduate quality dominated the expected graduate qualities to be achieved through the implementation of these subjects, in the current curriculum.

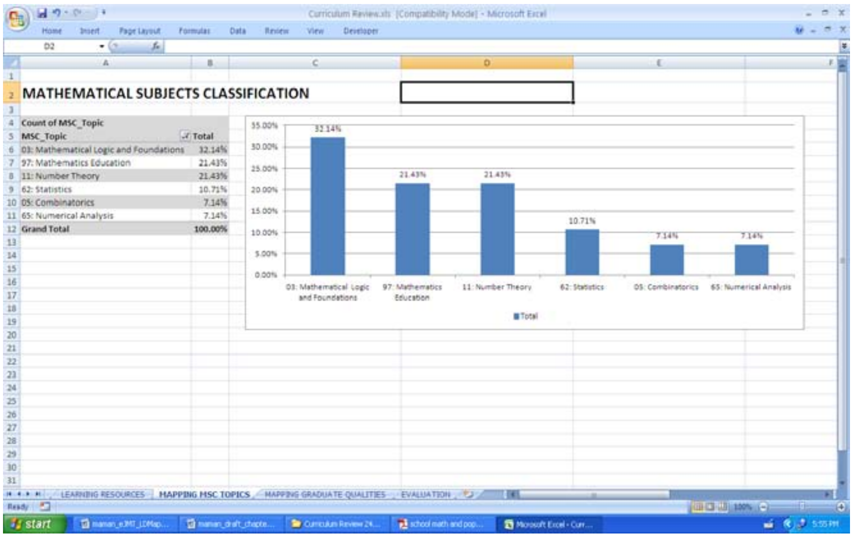

Figure 11: Mathematics Curriculum Review with Regard to Mathematical Subjects Classification

For Mathematics Subject Classification, the item Mathematical Logic and Foundation counted at 32.14%. This means that for these two example subjects, this classification item is dominated by the mathematics logic foundation rather than other items, perhaps reflecting the lecturers or teachers skills in this area.

However the above results are only partial results with example of only two subjects. If this system is implemented for all subjects in the school or department of mathematics, then the results are reflects overall condition. The result can be use for school or department self-reflection or evaluation as part of mathematics curriculum review, based on the design of teaching and learning for each subject within this curriculum.

4. Discussion

The teachers' rated very highly their satisfaction with the idea, innovation, and characteristics of this product for both the LDMap and LDSoft. While the prototype has innovative appeal, and teachers like the idea the "satisfied as distinct to very satisfied" ratings suggest further improvements in features such as functionality, layout and implementation could increase the prospect of use by teachers.

The learning design maps could be used by schools, universities, or other academic institutions to map the learning designs of their subjects, providing a useful tool for curriculum design, re-design curriculum mapping and evaluation. These maps can provide a historical record of how mathematical teaching and learning experiences have been or are conducted in these academic institutions. This would permit future generation of teachers and lecturers, say 5 to 10 years later, to use these maps to learn how others organize and implement mathematics teaching and learning experiences.

New lecturers can implement teaching and learning experiences drawing on previously identified learning resources recorded and how the design of learning should be conducted in the maps constructed by skilled practitioners or they can also modify the maps of others to construct their own version to use in mathematics teaching and learning. The graduate qualities may change as new outcomes are defined.

In addition, the use of LDMaps can provide additional benefits to the school or department by providing a way to conduct mathematics curriculum review based on the each subject learning design. Since the learning design data of all subjects can be easily imported to the one place or worksheet, then there are many possibilities to working with this data to review the curriculum based on learning design data of each subject aligned to the curriculum. It would also be entirely feasible to automate the process of producing student information sheets, as a subject information handout given by a lecturer for students in the first meeting.

Since each school or department of mathematics may require their own version of LDMaps, the LDMaps must be modifiable. Hence the ability to modify the LDMap, LDSoft, and tool Curriculum Reviewer become important along with documentation to reuse the LDMap. The manner in which LDMap may be modified is provided. Users (educator and their institution) can modify the LDMap by modifying the nodes (illustrated in Figure 3) used in LDMap using notepad or XML Editor and modifying the nodes used in spreadsheet with MS Excel. As long as the nodes in LDMap, LDSoft, and Curriculum Reviewer are consistent, the prototype should be work as required.

5. Conclusion

A prototype piece of software has been developed to document and create maps of learning designs so as to enable the sharing of mathematical teaching and learning designs. With the level of technology available these maps are suitable for use by teachers in developing countries such as

Indonesia to support teacher-centred learning with technology. These maps can be created by teachers and can be shared with and modified by other teachers. Furthermore, through mapping assessments, outcomes, resources and other attributes as considered desirable in the LDMaps, curriculum review can be facilitated.

5. Acknowledgement

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Supplemental Electronic Materials

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