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, a Learning Design Map (LDMap) to document and share mathematical teaching and learning experiences is proposed. These maps are intended to be used by mathematics teachers in developing countries. The development of the map 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. Teachers can create LDMaps. It is expected that the maps will be shared and modified by teachers and that there will be a circulation of the documentation of mathematical teaching and learning experiences among teachers through the use of this map. The 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 desirable, the LDMap can be designed to facilitate curriculum review. The benefit of the use of LDMap 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 many practices in human life, including in education. In this field, technology has been adopted not only in universities but also in secondary and primary schools. It is highly desirable that the emergence of new technology positively influences learning experiences [1]. In order to facilitate the sharing of a high quality learning experiences, technology-supported 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 the

US, UK, Japan, or Australia it is relatively easy to implement these because internet access is readily available to support online platforms or activities, however for some developing countries such as Indonesia, Vietnam, Kenya or Nigeria, it is problematic because internet access in these countries is generally poor.
According to the IMF [3], there are 34 countries in advanced economies and around 150 countries are classified as emerging and developing countries.

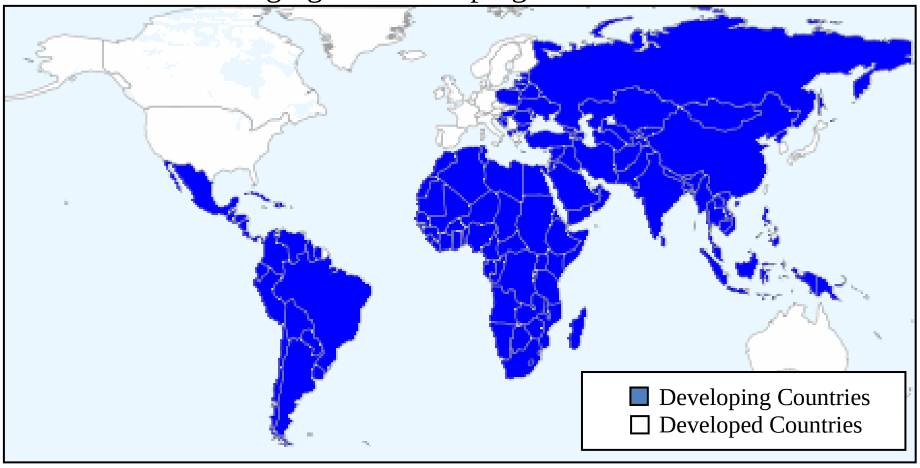

Figure 1: distribution of emerging and developing countries in the world

This data shows that 82 per cent 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 purpose of this research project is to provide appropriate technology for use by mathematics teachers in developing countries to document and share learning designs. To achieve the purpose of this research, an appropriate method of study is required. Design and development research can be used to provide appropriate technology for use by mathematics teachers in developing countries. As stated in [4]

> *Design and development research can be defined as the systematic study of design, development, and evaluation processes with the aims of establishing an empirical basis for the creation of instructional and non instructional product and tools and new or enhanced models that govern their development [4]*

According to [4], the process of design and development requires participation of practitioners, and is conducted in their own natural working environment. The practitioners of this research are mathematics teachers in their natural working environment in developing countries. The complexity of design and development research has led the researchers to implement a mixed methods approach using both quantitative and qualitative methods. Mixed methods is defined by [5] as "research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches and methods in a single study or program inquiry. Building on data collected in one accessible area of a developing country, the design and development of ICT-based tools for use by mathematics teachers was undertaken with a view to use more broadly in developing countries.
The implementation of the technology requires infrastructure, facilities, and resources, and these needs to be identified when planning the use of technology. These terms are defined by Oxford Dictionaries [6] 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 needs to be identified. Facilities for teaching include computer laboratories, 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.

The survey with 119 respondents was conducted in Bojonegara Sub District, Indonesia in October 2010 to February 2011. According to [7] 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-Centred Learning with Technology is the most appropriate method of technology-based learning to be implemented in Bojonegara Sub District, Banten Province Indonesia [7]*

According to [8] there are five technology-based learning methods available. These methods are based on the concept of learner control.

Table 1: *matrix of Technology-Based Learning Methods*

Technology-Based Learning Methods			
Learning Method	**Centre 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, hypermedia & 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 [8]

In Bojonegara Sub District, where the data were 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 [7]. Based on these survey results and discussions, 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, 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 of a teacher-centered mode.

It was also 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 curriculum developers can use the maps 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 most 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 proposed mapping is different from the direct instruction mathematics program because it provides the mapping of resources, tasks, and supports for teachers whereas the direct instruction program covers step by steps activities.

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

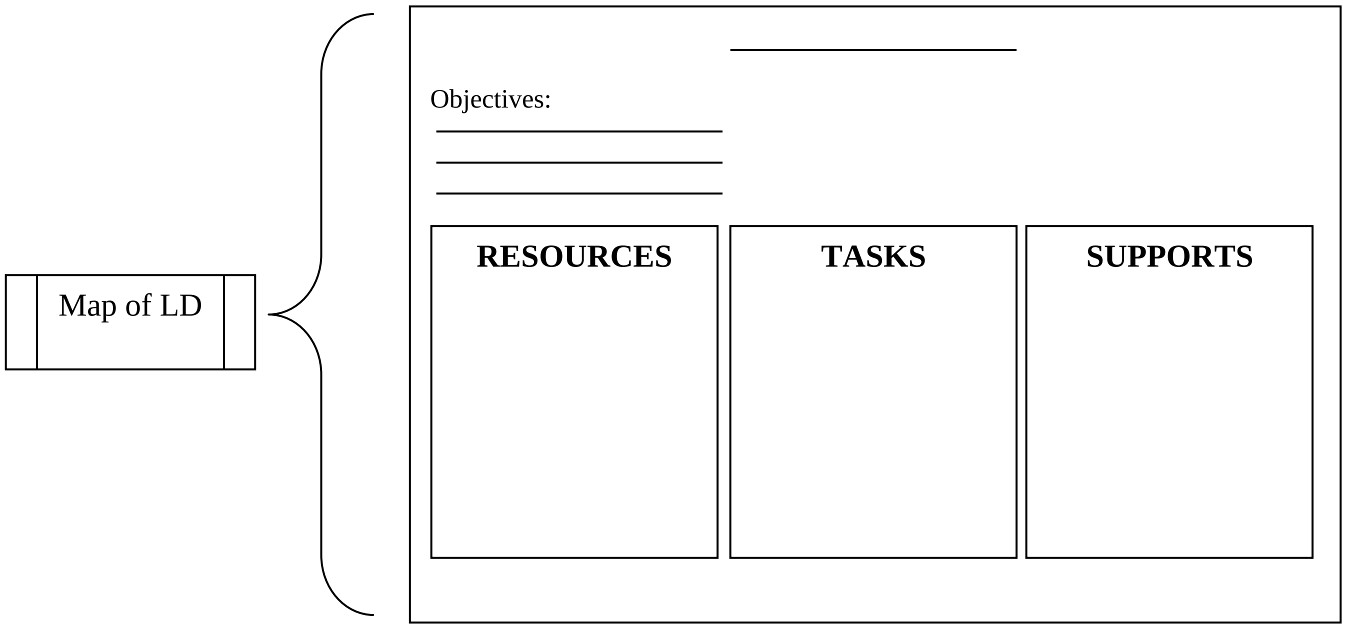

Figure 2: a Concept of Map of Learning Design

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, and in this case the data is the content teachers or curriculum designers supply to the learning design map. It is also possible to make the learning designs map and the learning design data contained in this map available across platforms, not the Windows platform, but also the Mac and Internet platforms. Visual Basic has been used to develop a windows-based application to read the map.

A software associate reader, called LDSoft, has been designed for the specific purpose of reading the learning design map called LDMap. The software associate reader is produced 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 [7].
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 name of each node itself is modifiable to satisfy the needs of teachers or their schools. However, consistency of the name of the nodes is required to avoid problem in data aggregation for curriculum review across multiple subjects. It is recommended that teachers or educators from same school or unit of teaching use the same nodes of LDMap (see section 3 the use of LDMap for curriculum review).
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 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. In choosing the teachers to include, the researchers considered teacher ICT skills and their school ICT facilities. 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 the research. One mathematics teacher from senior secondary school resigned due to illness, so the number of mathematics teacher participants from senior secondary school fell 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 participating in the research is not exactly the same as sought through sample estimation, with less in the senior secondary and more in the elementary school level. However these were considered viable numbers in terms of completing the project and representing different infrastructures available in the schools.

The 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. Participating mathematics teachers represented 8 (66.7%) of the available grades in school levels.

For each teacher, general information (gender, grade of teaching class, ownership and type of computers used at school and at 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

1. Idea
2. File Structure
3. Characteristics
   a. Creating Curriculum-aligned and non Curriculum-aligned Learning Designs
   b. Convert able to HTML
   c. Modifiable and Shareable ability
4. Function
5. Innovation
6. Implementation

The Software associate reader of Electronic Maps

1. Idea
2. Layout of Software
3. Characteristics
   a. Connection to Electronic Maps
   b. Using XML Technologies
   c. Record Learning Designs for Each Session
4. Function
5. Innovation
6. Implementation

Teachers evaluated the prototype LDMap 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

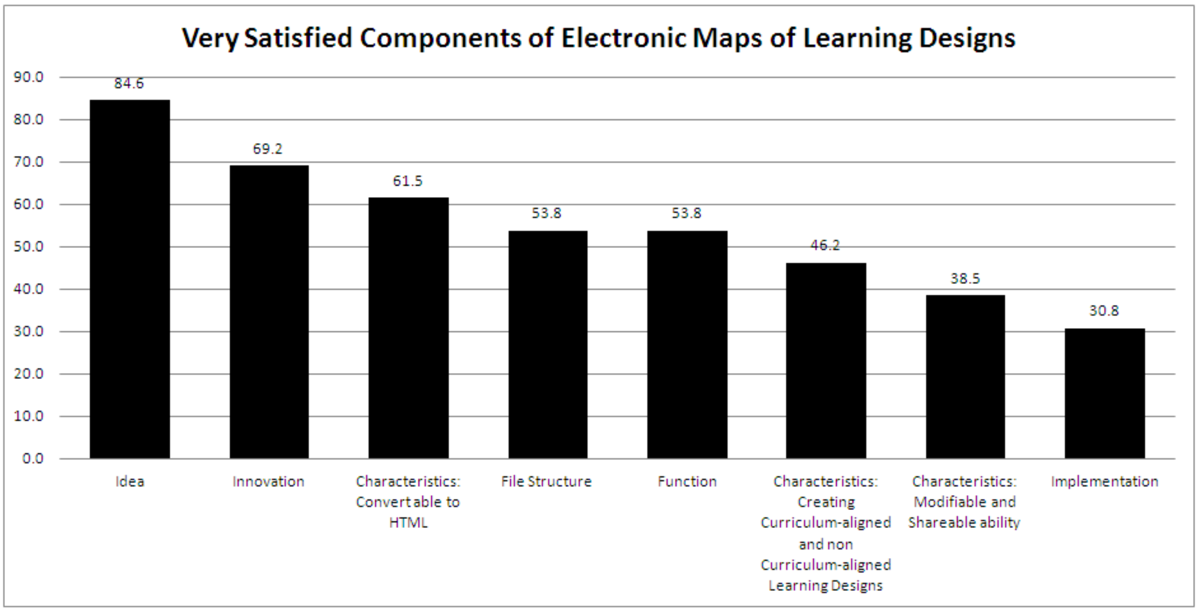

Figure 4: Very Satisfied Components of Software associate reader of Electronic Maps

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

Table 6: *teachers' Satisfaction of 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

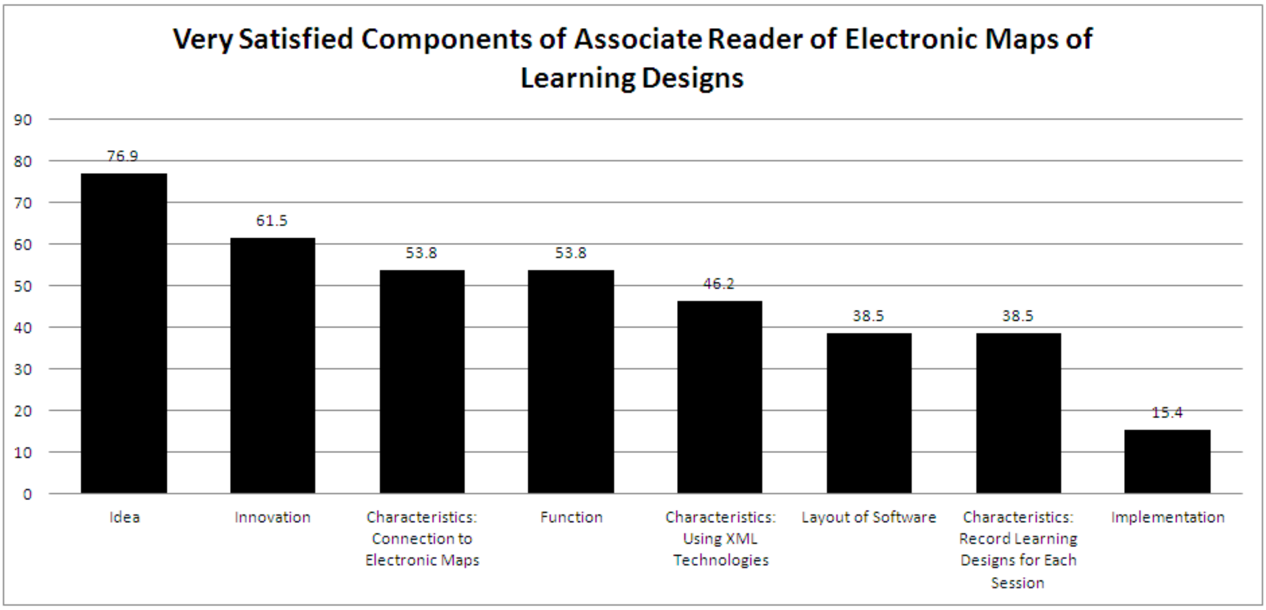

Figure 5: very Satisfied Components of Software associate reader of Electronic Maps

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 educators. The data can be extracted across operating system platforms and the internet using software which is able to extract data from XML files. One such piece of software

capable of extracting data from LDMap is Microsoft Office. According to [10] the XML capabilities in Microsoft Office bring the following benefits: 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 as such is able to enhance the applications related to the use of learning design data. One possible use of the data from these LDMaps is the review of mathematics curriculum.
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, with each LDMap associated with one subject as illustrated in Figure 6.

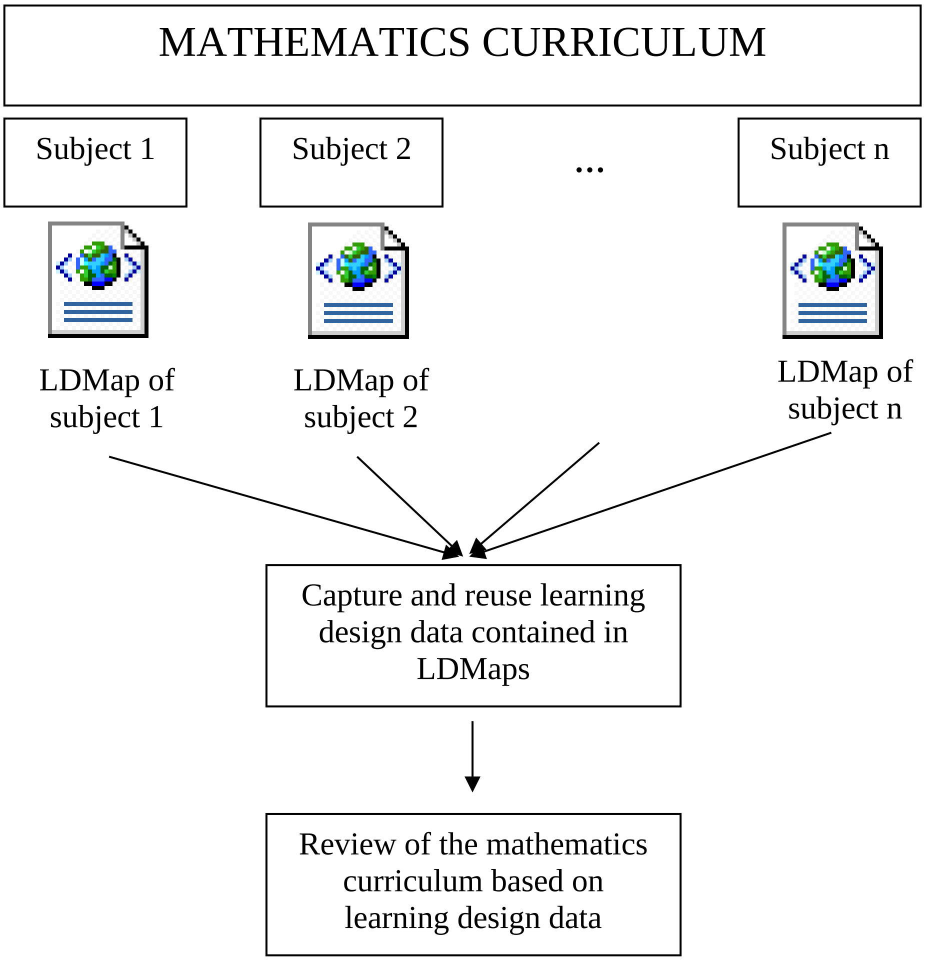

Figure 6: *concept of the Use of LDMap in Curriculum Review*

A tool developed, based on Microsoft Excel is used to extract learning design data from LDMaps. It would also be entirely feasible to automate the process of producing student information sheets or subject outlines for students. 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)

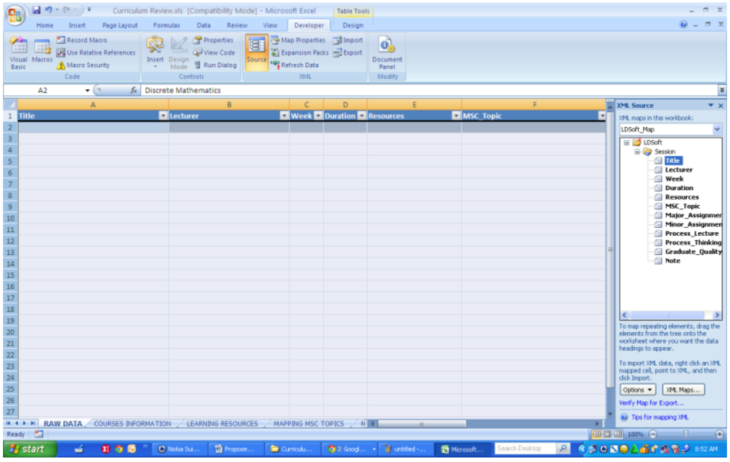

Figure 7: Curriculum Reviewer

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

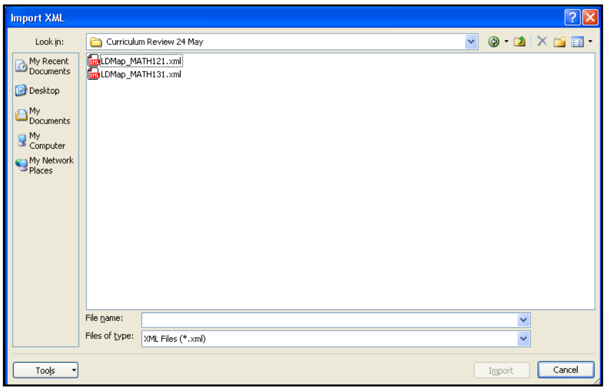

Figure 8: *process to Import All LDMap files to Curriculum Reviewer*

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

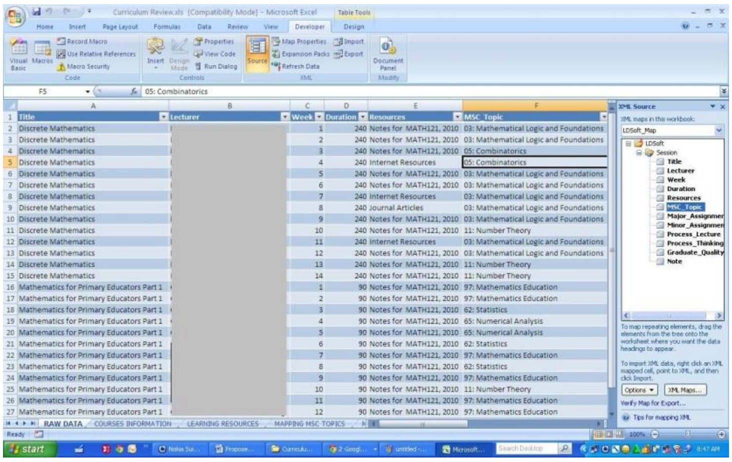

Figure 9: *imported Data from LDMap Files*

4. Then the data will be automatically analyzed by the spreadsheet. Currently in accord with the LDMaps five types of 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 Resources
   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 [11]. 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 the distribution of graduate qualities expected through implementation of the curriculum.

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

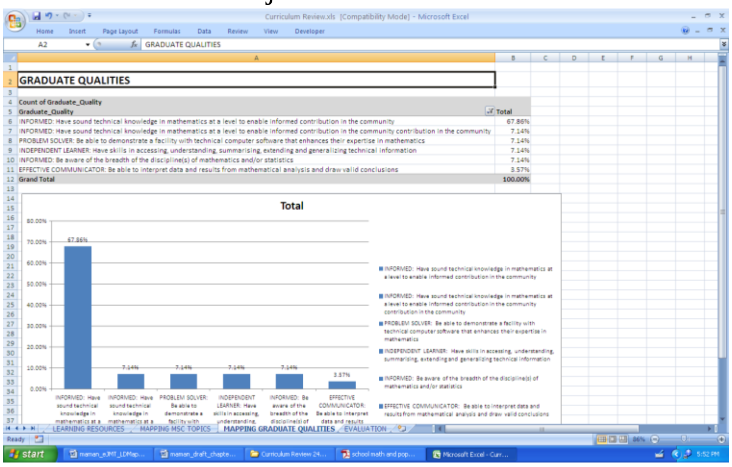

Figure 10: *mathematics Curriculum Review with Regard to Graduate Qualities*

For example, given the two subjects Discrete Mathematics (MATH121) and Mathematics for Primary Educator (MATH131), the results of a 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.

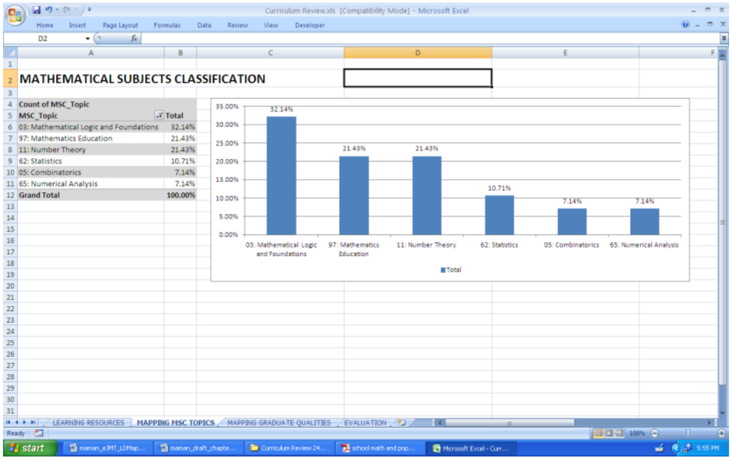

Figure 11: *mathematics Curriculum Review with Regard to Mathematical Subjects Classification*

For the Mathematics Subject Classification, the item Mathematical Logic and Foundation counted for 32.14% of the content. This means that for these two example subjects, this classification item is dominated by the mathematics logic foundation rather than other topics, 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 composition of topics or breakdown of graduate qualities addressed. The results 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 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 regarding reuse of the LDMaps. The manner in which LDMap may be modified is provided. Users (educators and their institutions) 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 product 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, curriculum review can be facilitated through mapping assessments, outcomes, resources and other attributes as considered desirable in the LDMaps,

5. Acknowledgement

Maman Fathurrohman's permanent address is at Universitas Sultan Ageng Tirtayasa, Indonesia. The first author acknowledges DIKTI Scholarship to undertake study at University of Wollongong, Australia, financial support from ICME Grant and the Centre for Statistical and Survey Methodology (CSSM), School of Mathematics and Applied Statistics, University of Wollongong, Australia for participation in ICME 12, 8 – 15 July 2012 in Seoul, South Korea, and financial support from Soaring Eagle Project Faculty of Informatics UOW for journal paper writing.

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Supplemental Electronic Materials

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