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Creating and modifying mathematical learning resources and learning designs for use in developing countries

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CREATING AND MODIFYING MATHEMATICAL LEARNING RESOURCES AND LEARNING DESIGNS FOR USE IN DEVELOPING COUNTRIES

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By

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DECLARATION

In accordance with the regulation of the University of Wollongong, I, Maman Fathurrohman, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy at the School of Mathematics and Applied Statistics, University of Wollongong, is my own original work unless otherwise referenced or acknowledged. It has not been submitted for qualifications at any other academic institution.

Maman Fathurrohman

PUBLICATIONS

Three journal articles and three conference papers have been raised from this PhD thesis so far.

Journal articles:

[1] Fathurrohman, M., and Porter, A. (2012). Addressing the Needs of a Developing Nation: Electronic Maps of Mathematical Learning Resources Accessible Via the Internet. **Journal of Computers in Mathematics and Science Teaching (JCMST)**. Volume 31, No 4. Pp. 337-362.
   a. Available at: *http://www.editlib.org/p/38433/*
   b. The Excellence in Research of Australia (ERA) 2010 Ranked B Journal.

[2] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Learning Design Map (LDMap) for Mathematics Teachers in Developing Countries and the Benefit of Its Use for Curriculum Review. **The Electronic Journal of Mathematics and Technology (EJMT)**, Vol 8, No 2. Pp 88-101.
   a. Available at: https://php.radford.edu/~ejmt/deliverAbstract.php?paperID=eJMT_v8n2a2
   b. The Excellence in Research of Australia (ERA) 2010 Ranked B Journal.

[3] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Comparison of Guided Hyperlearning, Unguided Hyperlearning and Conventional Learning in Mathematics: An Empirical Study. **The International Journal of Mathematical Education in Science and Technology (iJMEST)**. Online Publication: 16 December 2013.
   a. Available at: http://dx.doi.org/10.1080/0020739X.2013.868541
   b. The Excellence in Research of Australia (ERA) 2010 Ranked A Journal.

Conference papers:

[1] Fathurrohman, M., and Porter, A. (2011). Modifiable and Shareable Electronic Maps of Mathematical Learning Resources for Use in Developing Countries; A Case Study of Bojonegara Sub District, Indonesia. **The World Conference on Educational Multimedia, Hypermedia and Telecommunications, June 28 – July 1, 2011, Lisbon, Portugal.**
   a. Available at: *http://www.editlib.org/p/38098/*
   b. Full Paper in Section Case Study: Country Specific Developments.

[2] Fathurrohman, M., Porter, A., and Worthy, A., L. (2012). Maps of Learning Design for Teachers in Developing Countries to Document and Share Mathematical Teaching and Learning Experiences. **The 12th International**

Congress on Mathematical Education (ICME-12), July 8-15, 2012, Seoul, South Korea.

a. Available at: *http://icme12.org/upload/UpFile2/TSG/0573.pdf*
b. Full Paper in Topic Study Group 18: Analysis of the use of technology in teaching mathematics.

[3] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Meta-development of Resources and Learning Designs: Providing ICT-based Tools for Use by Mathematics Teachers. **The 23rd International Conference of Society for Information Technology and Teachers Education (SITE). March 25-29, 2013, New Orleans, Louisiana, United States of America.**

a. Available at: http://www.editlib.org/p/48577
b. Full Paper in Section Information Technology Diffusion/Integration.

ABSTRACT

The motivation for this study was the desire to take steps to reduce the digital divide between developing and developed countries. Huge differences exist between information and communication technology infrastructure and resources in advanced economies compared to those of developing countries. To facilitate economic development, improvements in information and communication technology use and quality of mathematics education, which contribute to country competitiveness, are considered essential.

The aim of this study was to identify ways to support the use of technology by mathematics teachers in developing countries. The Alexander and Hedberg evaluation of innovation model framed the study. The model involved the determination of teacher needs for ICT, evaluation at the design and development phases of innovation, teacher implementation of the tools and the institutionalisation of the innovation. Therefore the research approach involved several stages.

In the first stage, to determine needs, a review of recent surveys of ICT in developing countries was supplemented by a localised study of 119 Indonesian teachers' awareness of ICT infrastructure, facilities, and resources. It was determined that teachers in developing countries are able to operate computers and other ICT-based tools, although ICT infrastructure, facilities and resources in their schools or area are generally poor. Empowering teachers to use their own ICT-based tools for teaching and learning was considered important. Through the localised study it was determined 93.3 percent of teachers wanted to be able to share other teachers learning designs, and complementing this, result of interview stated that internet has become source of learning resources for teachers. It was therefore determined one way to support teachers was through the development of tools to enable the mapping and sharing of learning designs and resources.

The second stage involved the design and development of a set of electronic mapping tools. One tool was to map learning resources (called GRMap) and a second tool was to map learning designs (called LDMap). The design and development of electronic mapping system was focused in Bojonegara Sub District, Indonesia, recognising that the tools developed were to a great extent context bound for use in developing countries. The tools were tested through case studies conducted with 13 mathematics teachers. Evaluation of the tools in Indonesia, suggested that the involved teachers were satisfied with the tools' components. The teachers found the tools appropriate, given accessible ICT infrastructure and facilities, for use by mathematics teachers and further that these tools are appropriate for use by teachers for sharing mathematical learning resources and learning designs. Mathematics teachers agreed that the prospects for implementation and sustainability of the use of the tools in the long term were good. However the usability aspect of the tools was less satisfactory

than other aspects. This initiated a third stage of work addressing the usability of the tools.

This final stage to ensure institutionalisation of the tools involved the demonstration of the usefulness of the tools in four contexts: guided hyperlearning; mapping of national curriculum; curriculum review; and, the creation of embedded mathematics learning support systems. With each refinement of the tools to improve functionality was also undertaken.

The first study with 115 university students, through conventional learning, unguided hyperlearning and guided hyperlearning, demonstrated that the mapping tools could be used to teach via guided hyperlearning as effectively, in terms of performance as conventional teaching. In the second demonstration of use the conceptual aspects for mapping and aligning resources and learning designs for the Indonesian national curriculum were identified. Subsequent demonstrations undertaken in a developed nation, Australia, were used to define additional developments and to identify potential future developments. The mapping tools were further refined and a Learning Design Form (LDForm) developed. This was used to capture learning design data that could be output to produce a Subject Information Sheet, and converted to create Learning Design Map (LDMap) that in turn could be input into a curriculum review. The analysis of multiple LDMaps formed the basis of a curriculum through use of an additional tool, Learning Design-based Curriculum Reviewer (LDCR) that produced summaries of graduate attributes and topics taught. Further exploring uses, an embedded learning support system was developed for students to access mapped and verified learning resources.

Finally addressing the needs of different institutions and users documentation was provided. To complete the process addressing the needs of developing nations the documentation available in both the Indonesian language, the native language of country which was the focus of this study, and English, the universal language used by many developing nations in the world.

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CHAPTER 1. THE PLIGHT OF PEOPLE IN DEVELOPING COUNTRIES: AN ISSUE FOR MATHEMATICS

This chapter is framed in terms of the imperative to improve the plight of people who live in developing countries. It addresses the two needs, the need to reduce the 'digital divide' and the need for a more mathematically developed population in order to facilitate economic growth and development. The role of information and communication technologies and other key factors in the teaching and learning of mathematics are examined.

1.1 Developing countries

People in the world are living in different cultural, social, economic, and geographic situations. Their daily lives are affected by the conditions in which they are living in their home country. Each country in the world has its own living standards, and those standards depend on many factors, including the country's wealth and technological advances. Given their different characteristics there is a huge contrast between countries living standards.

Growing awareness as to the contrast in living standards experienced by people has lead to a classification of countries as developing or developed. The classification is usually based on countries' wealth, although there are difficulties in attempts to distinguish between poor and rich countries; should the wealth be measured only in terms of the money and material possessions it will buy, or should spiritual and cultural values be counted (Dickenson, Clarke, Gould, et al, 1983). In practice, although using different methods, from the World Bank in 1980 (Dickenson, Clarke, Gould, et al, 1983) until the IMU (International Mathematical Union) in 2012 (ICMI, 2012), the classification of the poor, low-income, or developing countries is based on monetary criteria.

According to the IMF (2010), there are 33 countries with advanced economies while 150 countries are classified as emerging and developing countries. This equates to 82 per cent of countries in the world being classified as developing countries. As displayed in Figure 1.1, developing countries populate most areas in the world.

Figure 1.1 Geographical location of developing countries (blue) in the world

As stated by Gonzales and Shere (2004, p.1) distinguishing between developed and developing regions of the world is not always easy and is normally an economic one. However many other factors, such as demographics, quality of life, and social infrastructure, also should be taken into account. According to Gonzales and Shere (2004, p. 56), developing countries, which include regions of the Middle America, South America, Africa, Middle East, Central Asia, South Asia, South East Asia, and the Pacific, are less wealthy and less technologically advanced than the developed countries. The difference in technological advancement, especially in Information and Communication Technology (ICT), has lead to what people have come to call the digital divide.

1.1.1 The digital divide

The OECD (Organization for Economic Co-operation and Development, 2000) viewed the differences between advanced countries and developing countries by considering ICT as important to both economic and social development of a country. The OECD has identified the priority of bridging what has come to be known as the "digital divide" (OECD, 2000, p. 3). Huge differences exist between ICT infrastructure and resources in advanced economies compared to those of developing countries in which technology access and use is often poor.

Table 1.1 People with internet access in a selection of countries

Rank[2]	Name of country	Type of country	Percentage of people with internet access	
			2010[1]	2012[2]
17	Japan	Developed Country	58.7%	79.5%
18	Australia	Developed Country	54.0%	79.0%
20	United States	Developed Country	66.3%	77.9%
91	Nigeria	Developing Country	1.4%	28.4%
100	Indonesia	Developing Country	6.5%	18.0%

Source: [1]World Data, Encyclopaedia Britannica Ultimate Reference Suite 2010 and [2]Rank of year 2012 (Schwab, 2012, p. 491)

For example, as shown in Table 1.1, the proportion of a countries population that are internet users differs greatly between developed and developing countries. It is also notable that the change in the proportion of internet users from 2010 to 2012 shows rapid growth.

The spread of Information and Communication Technologies (ICTs) has influenced the provision of education, in both developed and developing countries. Differences between these countries in ICT have resulted in developing countries experiencing greater disadvantage than developed countries. As a population skilled in mathematics and science are considered important in terms of countries competitiveness (Schwab, 2012, p. 7), this difference in ICT and its use is problematic particularly in mathematics and science education, because better education in turn leads to economic development.

1.1.2 The essential of mathematics and ICT for economic development

According to Schwab the factors that drive the productivity and competitiveness of a country (2012, pp. 4-6) can be grouped into 12 pillars of competitiveness: 1) Institution, 2) Infrastructure, 3) Macroeconomics environments, 4) Health and primary education, 5) Higher education and training, 6) Goods market efficiency, 7) Labour market efficiency, 8) Financial market development, 9) Technological readiness, 10) Market size, 11) Business sophistication, and 12) Innovation. The quality of mathematics and science education, the fifth pillar, is crucial for economies that want to develop beyond simple production processes and products, toward nurturing pools of well-educated workers who are able to perform complex tasks and adapt rapidly to their changing environment and the evolving needs of the economy (Schwab, 2012, p. 5).

The ICT use component, as part of the ninth pillar and key to countries' overall technological readiness, is important for increased efficiency and enabling innovation. ICT is often considered as general purpose technology contributing to countries competitiveness (Schwab, 2012, p. 6). In addition, the essential nature of

ICT for economic development has given rise to what is known as the digital economy. The digital economy refers to an economy that is based on digital technologies, including digital communication networks (internet, intranets, and extranets), computers, software, and other related information technologies (Turban, King, Mackay, et al, 2008, p. 18). ICTs have significant impacts on social and economic development (Mbarika, 2004, p. 3). Accessibility and exposure to technologies is closely related to socio-economic development to achieve adoption and diffusion of technologies for human development (Musa, Meso, and Mbarika, 2005, p. 598).

1.1.3 Mathematics teaching and learning

The teaching and learning of mathematics is also integral to societies in both developed and developing countries. Many governments in these countries have programs or initiatives such as national curricula to introduce mathematics into formal education. In addition, many governments have regulating standards requiring competency in mathematics to pass elementary and secondary school. The importance of mathematics continues through tertiary education, not only in mathematics undergraduate or postgraduate programs, but also in other discipline programs where subjects in mathematics become course requirements for the degrees in these programs. As the Editor of Chemical Education today (2008, p. 1019) stated mathematics is fundamental to science because many aspects of science are best described and elucidated using mathematical tools. Consequently, mathematics teaching and learning is important not only for mathematicians, but for all scientists.

The fundamental or core nature of mathematics, its compulsory acquisition, requires high quality mathematics teaching and learning experiences. Many institutions across the world, universities, teachers colleges, schools, and other public and private organizations, have programs that prepare prospective teachers who will teach mathematics at one school level or another (Ponte, 2012, p. 343). Chapman (2012) addressed four challenges in such mathematics education programs: 1) Implementing

new curricula, 2) Making connections to real world contexts, 3) Sustainable change and learning processes, and 4) Implementing technology. The last challenge emphasizes the importance for mathematics teachers of implementing technology in mathematics teaching and learning.

There are many key factors that need to be addressed when trying to improve mathematics teaching and learning. According to Ingvarson, Beavis, Bishop, Peck, and Elsworth (2004, p. 4) there are 15 factors as represented in Figure 1.2, which they group into three levels, student level, teacher and school level and system level, that contribute to effective mathematics teaching and learning in secondary school.

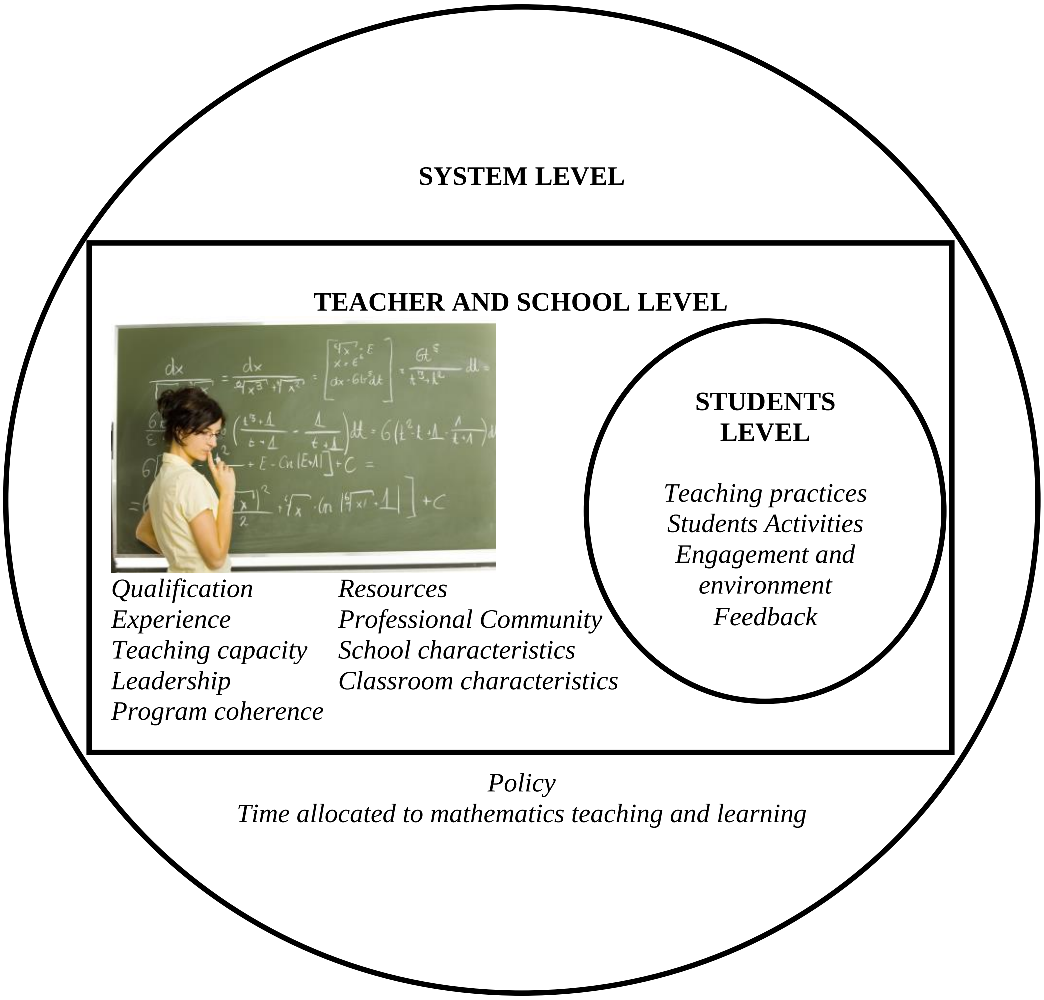


Figure 1.2 Key factors in effective mathematics teaching and learning.

In seeking to improve mathematics education and at the same time addressing the digital divide through the inclusion and use of ICT, two factors that could be manipulated by researcher during the project were identified. These key factors were: 1) Resources for teaching and learning and more generally, and 2) Teaching practices, how the students learn and/or how teachers teach mathematics. While the other factors, such as school characteristics and policy, in this instance, were deemed outside of researcher's influence.

The availability and access to mathematical learning resources for teachers and students is important, particularly from the perspective of resource based learning. Learning through a resource-based approach has highly desirable outcomes when an active learner confronts learning resources or set of resources.

> *[s]tudents independently might make decisions about problem solving or they might follow steps determined by the teacher to locate specific information.*
> *Resource-based learning effects information literacy. The information-literate student ably uses resources for extended learning*
>
> (Bleakley and Carrigan, 1994, p.4)

A decade ago most resources were printed while electronic resources were placed on CD or DVD or other electronic storage form such as microfilm. The process of locating and accessing such resources was through conducting extensive physical searches. In recent years, due to the emergence of new ICT technology, many resources are available as web-based resources and can be accessed through the internet. Web-based learning resources have been found to be useful for example, for competency development (Moen, Nygard, and Gauperaa, 2009), for peer support and collaborative knowledge construction (Moen, Smordal, and Sem, 2009), for enhancing interactivity and improving satisfaction (Kleinpell, Ely, Williams, Liolios, Ward, and Tisherman, 2011), enhancing student understanding and learning concepts (Callaghan, Lea, Mutton, and Whittlesea, 2011).

Teaching practices or how the teachers teach mathematics, including how they use resources and how students learn mathematics and about mathematics, are important in terms of generating solid learning outcomes.

1.1.4 Addressing the digital divide

Technology is ubiquitous, an integral part of people's activity in both developed and developing countries. The explosion of technology has changed the way people live and interact with each other. Czaja and Sharit (2013, p. 4) comment on the explosion of technology as follows:

> *Use of technology is pervasive and has become an integral component of work, education, communication, routine services, and entertainment. ... Finally, technology is influencing the implementation and format of training and instructional design"* (Czaja and Sharit, 2013, p. 4)

To reduce the gap, or address the digital divide, education and ICT are paramount (Marshall, Taylor, and Yu, 2003; OECD, 2005). It is also suggested that web pages and the internet can provide a bridge for rural and urban people to reduce digital divide (Akca, Sayili, and Esengun, 2007). Reports from several major or well-known projects or initiatives related to ICT for education in developing countries, along with several minor or country-specific projects or initiatives key recommendations suggest closing the gap will be through education and access to ICT. Furthermore, Thomas (2007) also suggested that new free software for teachers helps to close the digital divide because teachers are able to share educational materials and form communities. The survey reports used as references for this investigation are listed in Table 1.2.

Table 1.2 List of survey reports

No	Name of survey reports	Key findings
1	The Global Competitiveness Report year 2012-2013 by the World Economic Forum,	To reduce digital divide between developing and developed countries, two of twelve factors of country competitiveness, technological readiness and higher education and training, need to be improved.
2	Survey of ICT for Education in Asia and South Asia Countries year 2010 by InfoDev	Opportunity for minimizing digital divide can be provided through capacity building of the ICT resources was seen to ensure the availability and effectiveness of ICT-enabled educational interventions
3	Digital Review of Asia Pacific year 2009-2010 by International Development	To reduce digital divide low-cost devices and budget PCs were recommended as the appropriate technology for use in this region.
4	Survey of ICT for education in Caribbean year 2009 by InfoDev	Three important points are required for progressing ICT development to reduce the digital divide: 1) establishment of school level of ICT infrastructure, 2) improving capacity for ICT related project, and 3) improving impacts from regional initiatives.
5	Survey of ICT for education in Africa year 2007 by InfoDev	Providing ICT for education model appropriate to address the digital divide. Effective implementation of ICT in education in one region can foster other regions.
6	Reports and case study working papers for 13 countries, Argentina, Brazil, Kenya, Korea, Morocco, Nigeria, Philippines, Peru, Senegal, Sudan, Tunisia, Uganda, and Vietnam	Some case study and working papers in 13 countries emphasize that ICT itself is not enough to reduce digital divide. Capacity building through training and education to the people is also required.

1.1.5 Integration of ICT in mathematics teaching and learning

Many people have addressed the integration of ICT in education, but it does remain an issue for mathematics education even in developed countries such as Australia (Hudson, 2012). One early work by Setzer (1989) provided an early but comprehensive review of the arguments concerning the educational value of computers, such as computation power and possibility for computer-assisted instruction, for integration in education.

Discussion of this topic has been widespread with recent work by Finger, Russell, Jamieson-Proctor, et al (2007) on how ICT can be integrated to transform teaching

and learning processes, and by Duncan, Lockhart, and Ham (2012) on how ICT supports people to search with search engines for web-based resources, for use in education. Since Setzer's work, discussion has moved far from theoretical perspectives regarding educational value of computers to the more practical implementation of ICT integration in education.

Many researchers have been attracted to the topic of how to integrate ICT in education or how teaching and learning can be facilitated by ICT. Recent issues on the integration of ICT in teaching and learning has expanded the topics to areas relevant to this thesis, from the role of design and technology in teaching and learning (Eggleston, 2000) to evaluation of e-learning implementations (Psaromiligkos, Spyridakos, and Retalis, 2012).

While technology has a disputed role in mathematics education, people already implement ICT because it well accepted role in some aspects of education, including implementations to help training, professional development, and teaching and learning. The power of technology, especially ICT is of benefit to people who conduct complicated tasks as ICT makes these tasks easier (for example, data analysis using software), automates manual tasks (for example the use of spreadsheet for calculating a set of equations for different values of variables), and enhances results of work (for example, visualization of graphic functions). Given the dual context of developing mathematics and ICT being important to the reduction of the digital divide, it would appear reasonable for teachers and students in developing countries to take advantage from this explosion in technology to facilitate mathematics teaching. Concern about the inclusion of ICT in mathematics education often relates to the type of outcomes expected, how to include ICT in teaching and learning, and technical issues associated with ICT (Hudson, 2012).

1.1.5.1 ICT outcomes for stakeholders

Oldknow and Taylor in their book entitled *Teaching Mathematics with ICT* (2000) addressed the use of ICT with respect to the three groups of stakeholders, students,

teachers and schools who are affected by the inclusion of ICT in education. In the context of this thesis and the desire to reduce the digital divide, a fourth, the nation can be included.

In terms of students, two questions when contemplating the introduction of ICT into teaching should be posed by teachers:

1. *Pedagogical: can it be used to help teach content, to develop concepts, to increase knowledge, to improve understanding, to practice and reinforce skills?*
2. *Mathematical: can it be used to compute results, to produce tables, to draw graphs, to solve problems, to manipulate expressions, to compute statistics?*

(Oldknow and Taylor, 2000, pp. 12)

Technology for technology sake has not been considered an appropriate reason for use; rather mathematical software has been developed and used to address pedagogical issues such as:

- engaging students' attention and to motivate them (Millard, 1998; Binnur, 2009; Barber, Bagsby, Grawitch, and Buerck, 2011; McGuire, 2011);
- stimulating student curiosity (Shanklin, 2008; Geer and Sweeney, 2012);
- encouraging students to develop their problem-solving strategies (Allen, 1996; Peterson and Palmer, 2011; GOK, 2012);
- improving student test and examination results (Wayman and Stringfield, 2006; Ferrer and Ferrer, 2012);
- understanding mathematical and science concepts (Drier, 2001; Bukova Guzel and Canturk-Gunhan, 2010; Dominick, Friedman, and Hoffman-Goetz, 2010);
- facilitating learning of, developmental mathematics (MacDonald, Vasquez, Caverly (2002)); descriptive statistics (Forster (2006); geometry (Tam, Lau, and Zhao, (2009) and Nason Chalmers, and Yeh (2012)); mathematics writing (McCarthy, (2008));

- clarifying concepts with the aid of concept mapping tools (Novak, (1990); Reader and Hammond, (1994); Khalifa and Kwok, (1999); Beaudrie and Boschmans, (2004)); and
- creating metacognitive awareness (Bendixen and Hartley, (2003); Deluca and Lari, 2013).

Much software has been developed and/or used to harness mathematical power so as to:

- educational purposes such as using the power of computing (Gander, (2004)); the philosophy of technology (Khadivi, (2006)); for simulation (Vahidi and Khorsandi (2010) using software such as Matlab, Maple, and/or Mathematica);
- manipulate data and statistical analysis with SPSS and SAS (Peng, Long, and Abaci, (2012); Saka, (2012)); and,
- educational purposes with a focus on specific aspects of or closely related to geometry such as mediated understanding of geometric transformation (Hollebrands, (2007)); conceptualisation of integers (Reisa, (2010)); parabola teaching (Reisa and Ozdemir, (2010)); conceptual and procedural knowledge of functions (Zulnaidi, and Zakaria, (2012)) with Geogebra, Cabri, and Geometer's Sketchpad as powerful package for Euclidean Geometry (Roanes-Lozano, Roanes-Macias, and Villar-Mena, (2003)).

The third question that teachers need to pose relates to organisational efficiencies and benefits to both teacher and schools:

> *Organizational: can it help to produce materials more efficiently, to keep records, to manage time, to communicate with others, to find resources?*
>
> (Oldknow and Taylor (2000, p. 12)

A variety of organisational tools have been developed and currently widely used to facilitating the integration of ICT in education and to support teachers in a variety of ways:

- online management systems, providing enhanced communication, access to resources, such as Moodle (Korte, (2009); Lin, (2011)), Blackboard (Bradford, Porciello, Balkon, Backus, (2006)); Tella, (2012)), Vista (McQuenn, and Fleck, (2004)); Garrett, (2004));
- resource management tools which store and make available through searches resources such as Equella (Jones, (2007); Gregory, Gregory, Campbell, et al (2010));
- quiz and assessment tools, providing impact to e-learning effectiveness (Wang, 2008);
- technology in general (computer, office software, internet) to reduce classroom administrative workload (Parizo, (2013));
- blogs and wikis as educational tools enable communication with other teachers allowing the sharing of information and common problems, while search engines perform the function of searching for resources. Both tools can be used to engage students in digital discussion and to create workspaces for collaborative projects (Flierl and Fowler, (2007));
- extensive or well developed websites point to resources, for example the dedicated website to History of Mathematics available at http://www-history.mcs.st-and.ac.uk/; and,
- Computer Assisted Language Learning (CALL) system improves provisions for students who are not learning in their native tongue (Ohkawa, Suzuki, Ogasawara, Ito and Makino, (2009)).

Some software tools are freely available, some may be partially available with extended features costing funds, while some is proprietary software involve considerable cost, at least for developing countries. Software that is targeted that can be used to help teachers search and map resources, create and share mathematical

learning resources effectively and efficiently, and/or which is able keep record of teachers' designs for learning is rarely known.

1.1.5.2 ICT uses in teaching and learning

The inclusion of ICT is considered as inevitable for mathematics teaching and learning. The use of ICT in itself can be considered as part of technology-based teaching and learning method. The role of computer technology in education, according to Cennamo, Ross, and Ertmer (2010, pp. 4-8), can be illustrated in four phases: the first phase is the computer as object of study (1977-1982), the second phase is the computer as programming tool (1983-1990), the third phase is the computer as a communication device and resource tool (1991-1996), and the fourth phase is the computer as learning and social tool (1997-current).

The implementation of technology can occur with many different teaching methods. Ross and Bailey (1995) proposed five technology-based teaching and learning methods. These methods are classified from the perspective of learner control and hence they have different outcomes, issues, and benefits (refer Table 1.3).

Table 1.3 Matrix of Technology-based teaching and learning

Technology-based teaching and learning Methods			
Learning Method	Centre of Control	World of Work Example	Strategies
Teacher-centred 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 Instructional Learning System, lab-centred Instructional Learning System
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 or electronic simulations

Recent advancements in ICT, such as better computer performance, the availability of a range of mobile devices, and faster internet connections has enabled educators and their institutions to take advantage of the integration of ICT in education, such as the use of ICT to facilitate distance and mobile learning. Advancement has been in terms of the dimension of mobility, with smaller portable devices, and cheaper prices of these devices for the integration of ICT in education. One concept that has been embraced many people is the concept of “bring your own device” (BYOD) or “bring your own technology (BYOT) as an economical way to reach larger number of audiences (Cennamo, Ross, and Ertmer, 2010, p. 213). Based on this concept, supported by the cheaper price of computer devices, teachers and students can use their own mobile devices and laptop computers for use in teaching and learning processes, an issue to be examined in this thesis.

1.1.5.3 Technical issues

The implementation of technology in the classroom is highly dependent upon the ICT hardware and software, and closely associated with this is the need for support staff and professional development. For that reason, technical issues related to hardware, software and support have to be recognised.

ICT hardware and software available to teachers and students need to be considered when implementing technology-based mathematics teaching and learning. A range of equipment that may be available for teaching and learning that is considered as ICT hardware include: 1) Stand-alone PCs, 2) Networked PCs, 3) Laptop computers, 4) Notebook (and sub-notebook) computers, 5) Palm-top computers, 6) Personal organizers, 7) Graphing calculators, 8) Whole class displays, 9) Data capture devices (such as scanners), and 10) Printers (Oldknow and Taylor, 2000, pp. 3-9). With recent progress in ICT, mobile technology such as tablet PCs, iPad and other tablet devices also should be considered in terms of hardware and software for education.

With respect to software, the DfEE/NCET (1997) published a review of software for mathematics. In the review software was grouped as follows: 1) Small software, a program aimed at specific, highly-focused, curriculum content, 2) Programming language, 3) Generic software, 4) Content-free, subject specific, such as Computer Algebra Systems (CAS) and Dynamic Geometry Software (DGS), 5) Courseware, 6) Graphics calculators, and 7) CD-ROM and the internet. Since then with the emergence of new applications, classroom management such as remote desktop, VNC, Moodle, Blackboard, resources storage and management Equella, markbooks, attendance, reports, asset tracking and bookings also should be considered as software for education.

Closely associated with hardware and software is the need for professional support including the documentation to support learning on how to use such tools, or fix them if they are faulty.

1.2 Research questions

Given the need to improve mathematics education in developing countries in order to facilitate economic growth and development, several research questions are to be addressed in this thesis:

1) What access to information and communication technologies do mathematics teachers in developing countries, and specifically in Indonesia, have to facilitate teaching and learning?

2) Given the level of technology available how can mathematics teachers in developing countries be supported in the introduction of technology to the mathematics classroom?

Initially the focus on developing tools was to map and share mathematical learning resources and learning designs, leading to the question:

3) In what ways can the introduction and provision of technology-based mapping tools for learning designs and resources contribute to improving mathematics education in developing countries and specifically Indonesia?

The software tools were trialled in Indonesia but the need to improve usability of the tools involved an exploration of use in Western cultures as the question arose:

4) In what ways can the technology-based mathematical learning resource and learning design tools be improved to be more usable and sustainable?

Improving usability involved expanding the uses to which the tools could be applied as well as the functionality and modifiability of each mapping tool, hence the following questions were posed:

5) Is there a difference in student learning outcomes when comparing traditional teaching to learning through the use of technology in resource-based learning?

6) How can the mapping of learning designs facilitate the mapping of curriculum?

7) What is required for the mapping of resources be used to create embedded mathematics learning support systems?

1.3 Evaluation framework

Research in this thesis can be classified as design and development research in the implementation of technology-based mathematics teaching and learning. Addressing challenges has been an important component of “innovation and exploration” (Jacobson, Angulo, Kozma, 2000, p.1), in this case addressing the need of developing nations for technology-based mathematics teaching and learning may considered as innovation and exploration in the field of mathematics education. Specifically, the process of this research lead to the creation of innovations related to technology-based mapping of mathematical learning resources and learning designs and through further refinement to curriculum mapping tools and tools to create embedded online learning support systems. In order to provide evidence of the impact of this innovation, an evaluation model for technology-based teaching and learning is required.

According to Alexander and Hedberg (1994, p.236), there are four types of evaluation models for technology-based teaching and learning:

1) objectives-based models

Evaluation is a process determining the degree to which educational objectives are being achieved. Refinement of courses and subjects become the major thrust of the evaluation.

2) decision-based models

Evaluation looks at a tool in term of context, input, process, and product. The evaluation focus is on the decisions made during the development and improvement. This model focuses on practitioner needs.

3) values-based model

Evaluation concerns not only achievement of goals but also whether the goals are worth achieving. The evaluator looks at the major effects, achievements, and consequences of the product.

4 naturalistic

Evaluation is organized around the participants' key concern and issues.

As the primary concern was the improvement of teaching and learning through the use of software tools a decision-based model, which examines user needs, was chosen. The process of evaluation, using decision-based models is conducted through activities and information gathering cycles as presented by Alexander and Hedberg (1994, p. 241) and as represented through activities and information gathering cycles in Figure 1.3.

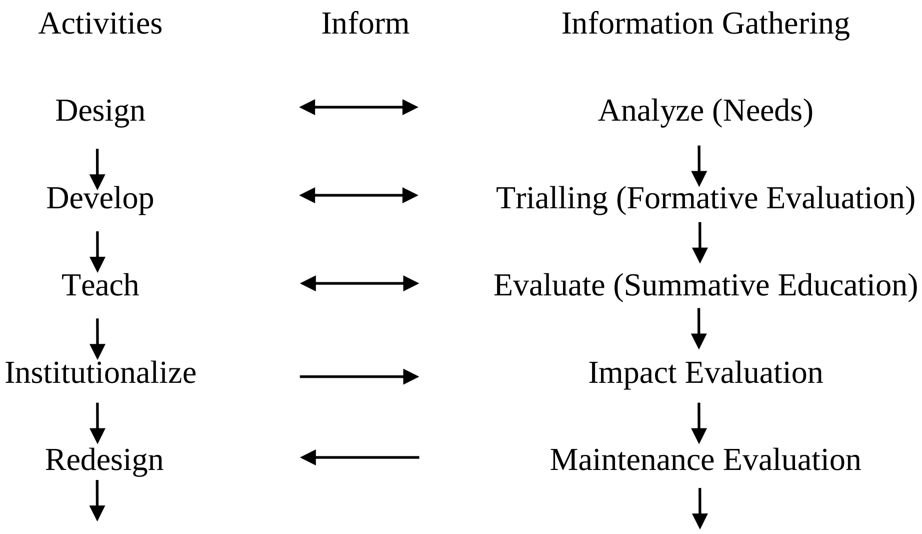


Figure 1.3 Activities and information gathering cycles

For the practical implementation of this research project the cycles were expanded. The purpose of each activity and data gathering cycles is presented in Table 1.4.

Table 1.4 The flow of activities in evaluation

No	Activity	Information gathering	Purpose
1	Design	Analyze	To gather information of the mathematics teachers needs in regard to technology-based mathematical learning resources and learning designs
		Formative Evaluation	To inform decisions made in relation to the design of the technology-based teaching and learning tools for use in developing countries
2	Develop	Formative Evaluation	
3	Teach	Summative Evaluation	To determine the worth of technology-based teaching and learning tools in the context of its use by mathematics teachers and students in an accessible area of a developing country
4	Institutionalize	Impact Evaluation	To determine the impact of the implementation of the technology-based teaching and learning tools in a developing country
		Maintenance Evaluation	To determine the usability and sustainability of the technology-based mathematics teaching and learning tools in the future.
5	Redesign	Improvement	To improve usability & sustainability through expanding uses to
6	Institutionalise	Impact	To demonstrate use in curriculum mapping To demonstrate use in the creation of embedded learning support systems
		Maintenance Evaluation	To improve modifiability and usability through the provision of documentation

To implement this research project and to gather appropriate evidence for evaluation, an appropriate methodology was required. One such appropriate method is design and development research.

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 tools and new or enhanced models that govern their development. This design and development is associated with a need for specific and appropriate technology for use by

mathematics teachers in developing countries. The design and development of technology-based tool consists of three main activities:

1) Discovering the current ICT condition in developing countries.

This activity initially consists of the compilation of survey reports regarding current ICT within these countries. These surveys are available from the World Bank and other international organisations and agencies. This information is then supplemented by observation of the real ICT infrastructure, facilities, and resources in one accessible area of a developing country in which the research was undertaken along with interviews with and surveys of teachers. The data collection was from registered teachers in one area of Indonesia. Results of the data collection, together with the recent results of literature reviews of ICT and recommendations for education in other developing countries are used as a rationale for the next research activity, design and development.

2) Design and development research.

This part of the process is conducted with a view to developing technology-based teaching tools intended to be functionally appropriate to current ICT situation in developing countries. Mathematics teachers in the same or similar areas of observation as undertaken in step 1) implement the tools developed as a result of this activity.

3) Leveraging the usability of the technology-based tools.

Activities in this stage are aimed at leveraging the usability of technology-based tool by examining the learning impact of the use of the tools through an empirical study with students accessing resources in the internet. The second sets of activities involves conceptualising the use of the tools to map learning learning designs and align them to curriculum in Indonesian context,

undertaking a curriculum review and facilitating the development of an embedded learning support system.

1.4 Thesis overview

The use of technology in developing countries is of necessity governed by access to ICT infrastructure. In order to know the big picture about the current ICT conditions in developing countries, a literature review of surveys and reports regarding ICT for education was undertaken. In Chapter 2 this review is reported, as well as a more detailed literature review about mathematical learning resources and learning designs, and the available technology for technology-based teaching and learning in developing countries.

In Chapter 3 the issues associated with the selection of a research methodology are discussed along with the choice of the study design. Four phases of investigation: 1) Identification of ICT conditions, 2) Development, 3) Implementation, and 4) Evaluation are explained in detail.

In Chapter 4 findings are presented with respect to 1) The infrastructure available for use in teaching and learning in one developing country, Indonesia 2) The suitability of tools developed to allow teachers to engage in mapping and sharing of mathematical learning resources and learning designs, 3) The experiences of teachers' trial use of the tools in their natural working environment, and 4) Evaluation of technology-based teaching and learning, through examination of how the tools were developed and implemented, and how these tools could empower mathematics teachers in developing countries to use their own ICT devices to facilitate technology-based teaching and learning.

In Chapter 5 ways to improve usability are explored. The technology-based tools are improved, their use extended and evaluated. In the first empirical study students are provided with a choice of learning approaches and teachers a choice in teaching approaches, with comparisons made of students' performance and satisfaction due to

guided hyperlearning (facilitated by the electronic mapping system), unguided hyperlearning (not facilitated by electronic mapping system), and conventional learning in mathematics. The second exploration is of the alignment of the maps generated by the tools for use in mapping curriculum in the Indonesian context. The third exploration with a view to further improvement in usability of the tools involves interviews with academic staff at University of Wollongong (a developed country) regarding staff experiences with curriculum review tools. The fourth extension of use involved the refinement of the electronic mapping system to produce an embedded learning support system. With respect to all tools developed, ICT appropriateness given developing countries is adhered to.

In Chapter 6, there is a return to a discussion of outcomes as they pertain to the evaluation framework with respect to design, development, implementation and redesign and potential for institutionalising the use of the tools. Dissemination strategies are discussed as a means of 1) Providing both the tools for use and 2) The sharing of designs and resources by mathematics teachers in developing countries and 3) Embedding the use of the tools. Recommendations as to how the tools can later can be developed and implemented by mathematics teachers in developing countries are provided.

CHAPTER 2. LITERATURE REVIEW

This chapter is framed in terms of providing a solid scientific base for the introduction of technology innovation into mathematics education in developing countries. It addresses the background and characteristics of developing countries, including compilation of recent, year 2007 to 2012, surveys results of or related to ICT for education in these countries. Literature related to associated theories of learning, mathematical learning resources and learning designs are also reviewed.

Understanding how to bridge the digital divide involves understanding both the nature of the divisions between developing and developed countries and the possibilities for improving education through the use of ICT. Both are discussed in this chapter.

2.1 Developed and developing countries: contrast

There are many ways in which developing nations are conceived of and many ways in which the divisions can be quantified. In this section developing nations are firstly identified, then key reports which have been used to examine their ICT status are identified and findings discussed both generally and with specific focus on ICT conditions, concluding with a specific focus on the Indonesia, the site for data collection in this study.

2.1.1 Developed and developing countries

Less-affluent countries have been variously called “backward”, “underdeveloped”, “undeveloped”, “less developed”, or “developing” countries when making comparisons with “advanced”, ”developed”, or “more developed” countries (Dickenson, Clarke, Gould, et al, 1983: 1). Other similar terms for the less-affluent countries are the “Third World”, proposed in the 1950s to distinguish them from the “First World” of industrialized, market economy countries or Western World, and the “Second World” of centrally-planned economies or the communist bloc, and the “South”, proposed in the 1980s based geographically on the world map, the north countries are usually rich countries and the south countries, except Australia, are the less-affluent countries. In this thesis, the term developing countries is used to describe less-affluent countries, and the categorisation of countries, as listed in Table 2.1 are accepted as developing or emerging countries according to the IMF (2010). These classifications are based on the development of a country, measured with statistical indexes, such as Gross Domestic Tool (GDP), life expectancy, and rate of literacy (education).

Table 2.1 List of developing countries

No	Name of Country	No	Name of Country	No	Name of Country	No	Name of Country
1	Afghanistan	39	Djibouti	77	Lesotho	115	Saudi Arabia
2	Albania	40	Dominica	78	Liberia	116	Senegal
3	Algeria	41	Dominican Republic	79	Libya	117	Serbia
4	Angola	42	Ecuador	80	Lithuania	118	Seychelles
5	Antigua and Barbuda	43	Egypt	81	Macedonia	119	Sierra Leone
6	Argentina	44	El Salvador	82	Madagascar	120	Solomon Islands
7	Armenia	45	Equatorial Guinea	83	Malawi	121	South Africa
8	Azerbaijan	46	Eritrea	84	Malaysia	122	Sri Lanka
9	Bahamas, The	47	Estonia	85	Maldives	123	St. Kitts and Nevis
10	Bahrain	48	Ethiopia	86	Mali	124	St. Lucia
11	Bangladesh	49	Fiji	87	Mauritania	125	St. V. and the G
12	Barbados	50	Gabon	88	Mauritius	126	Sudan
13	Belarus	51	Gambia	89	Mexico	127	Suriname
14	Belize	52	Georgia	90	Moldova	128	Swaziland
15	Benin	53	Ghana	91	Mongolia	129	Syrian Arab Rep.
16	Bhutan	54	Grenada	92	Montenegro	130	Tajikistan
17	Bolivia	55	Guatemala	93	Morocco	131	Tanzania
18	Bosnia and Herz.	56	Guinea	94	Mozambique	132	Thailand
19	Botswana	57	Guinea-Bissau	95	Myanmar	133	Timor-Leste
20	Brazil	58	Guyana	96	Namibia	134	Togo
21	Brunei Darussalam	59	Haiti	97	Nepal	135	Tonga
22	Bulgaria	60	Honduras	98	Nicaragua	136	Trinidad and Tobago
23	Burkina Faso	61	Hungary	99	Niger	137	Tunisia
24	Burundi	62	India	100	Nigeria	138	Turkey
25	Cambodia	63	Indonesia	101	Oman	139	Turkmenistan
26	Cameroon	64	Iran	102	Pakistan	140	Uganda
27	Cape Verde	65	Iraq	103	Panama	141	Ukraine
28	Cent. African Rep.	66	Jamaica	104	Papua N G	142	UAE
29	Chad	67	Jordan	105	Paraguay	143	Uruguay
30	Chile	68	Kazakhstan	106	Peru	144	Uzbekistan
31	China	69	Kenya	107	Philippines	145	Vanuatu
32	Colombia	70	Kiribati	108	Poland	146	Venezuela
33	Comoros	71	Kosovo	109	Qatar	147	Vietnam
34	Congo,	72	Kuwait	110	Romania	148	Yemen, Republic of
35	Congo, Republic of	73	Kyrgyz Republic	111	Russia	149	Zambia
36	Costa Rica	74	Laos	112	Rwanda	150	Zimbabwe
37	Côte d'Ivoire	75	Latvia	113	Samoa		
38	Croatia	76	Lebanon	114	São T. and P		

Classified by the IMF (2010) Table 2.2 displays the list of developed countries IMF (2010).

Table 2.2 List of developed countries

No	Name of Country	No	Name of Country	No	Name of Country	No	Name of Country
1	Australia	10	Germany	19	Luxembourg	28	Spain
2	Austria	11	Greece	20	Malta	29	Sweden
3	Belgium	12	Hong Kong*	21	Netherlands	30	Switzerland
4	Canada	13	Iceland	22	New Zealand	31	Taiwan
5	Cyprus	14	Ireland	23	Norway	32	United Kingdom
6	Czech Republic	15	Israel	24	Portugal	33	USA
7	Denmark	16	Italy	25	Singapore		
8	Finland	17	Japan	26	Slovak Republic		
9	France	18	Korea	27	Slovenia		

*Hong Kong Special Administrative Region (SAR) of the People's Republic of China

** Taiwan Republic of China

2.1.2 Surveys of and related to ICT for education

Before embarking on investigations to address ways of improving mathematics education in developing nations a literature search identified a number of major surveys. Surveys of, or related to, ICT for education in developing countries has been conducted by many organizations with reports generating recommendations, including recommendation regarding ICT for education. Examples include, The *Survey of ICT and Education* and country focused surveys in ten countries, Argentina, Brazil, the Philippines, Kenya, India, Morocco, Peru, Senegal, Ukraine, and Vietnam, that also provide data and information about recent ICT conditions in these developing countries, and surveys of India and seven other developing countries in South Asia, Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, and Sri Lanka by Information and Development Program or InfoDev (year 2007 to 2009, web address: www.infodev.org). A list of organizations that are regularly conducting surveys in developing countries and their relevant results of survey activities are provided in Table 2.3.

Table 2.3 List of organizations regularly conducting surveys in developing Countries

No	Name of Organization	Name of Relevant Data, Publications, Programs
1	Asian Development Bank (ADB)	Statistics, databases, and research publications related to developing countries in Asia, including their ICT conditions
2	Development Gateways	Resources from two online communities: 1. E-Learning, and 2. Open Educational Resources
3	Department for International Development (DFID), United Kingdom	Knowledge and Resources Bank of ICT activities in Africa, and Education Division Publications related to ICT
4	Inter-American Development Bank (IDB)	Statistics, databases, and research publications related to developing countries in Latin America and Caribbean, including their ICT conditions
5	Organization for Economic Cooperation and Development (OECD)	Statistics and OECD Fact books of countries in the world, including their ICT condition
6	United Nations Educational, Scientific, and Cultural Organization (UNESCO)	UNESCO ICT in Education Program (publications and products), including meta-surveys on the use of technologies in education in Asia and the pacific year 2003 – 2004
7	United States Agency for International Development (USAID)	USAID dot-EDU, the information and communication technology program seeking to assist developing countries in strengthening learning systems that improve quality, expand access, and enhance equity through carefully planned applications of digital and broadcast technologies
8	World Bank	Data related to education, science and technology of developing countries

Many organisations such as the World Bank, the organization that manages InfoDev, also provides raw data regarding developing countries in its website http://www.worldbank.org. The United Nations and its branch organisations (such as UNESCO) also provide similar data and information for many developing countries in the world. Other organizations only focus on specific area in developing countries or on specific aspects of ICT in developing countries. For example, the Department of International Development (DFID) of United Kingdom focuses on developing countries in Sub-Saharan Africa, while the United States Agency for International Development (USAID) provides dot-EDU program that seeks to help developing countries in implementing ICT for education. Actual and recent data regarding ICT for Education in developing countries is useful as a foundation for research that

involves technology-based mathematics teaching and learning in developing countries. In addition, Marshall (2009) in editorial note also addressing potential and challenges in the use and adoption of ICT, mostly in education, for cases from Australia, Guyana, India, Iran, Jordan, Malaysia, Nigeria, Pakistan, Singapore, South Africa, Sri Lanka, Sultanate Oman, Turkey, and USA.

In order to understand the current ICT situations in developing countries, survey reports compiled in chapter 2 of this thesis are recent published from year 2007 to 2012. These surveys, canvassed data related to eight aspects of ICT and education. These aspects are: 1) The education system, 2) ICT policies, 3) infrastructure, 4) ICT initiatives and projects, 5) Implementation of ICT in education, 6) Policy planning, 7) Teaching professional development, and 8) Barriers and challenges of ICT in education. Data were collected from 53 developing countries in Africa and 16 developing countries in Caribbean.

The published reports of surveys (refer Table 2.4) also comprehensively addressed current usage of ICT in primary, secondary and tertiary schools and pre-service and in-service teaching professional development in these countries. Some sections of reports briefly discussed regional and global trends of ICT in education and selected regional ICT initiatives and projects in education. In addition to the surveys several studies related to ICT and education in developing countries are also provided by InfoDev, for example three studies that are relevant to this thesis are: 1) *Knowledge maps: ICT in Education*; 2) *ICT in school education (primary and secondary)*, and 3) *Monitoring and Evaluation of ICT in Education*. The statistics provided by the World Bank through InfoDev includes the condition of ICT in these countries. Some regional based organizations, such as the Asian Development Bank (ADB, web address: http://www.adb.org) and the Inter-American Development Bank (IDB, web address: http://www.idb.org) also provides statistics, databases and related research publications of developing countries around their working area. ADB provides data statistics of developing countries in Asia, while IDB provides data statistics of developing countries in Latin American and Caribbean.

Table 2.4 List of recent reports of surveys conducted in developing countries

No	Name of Survey Report	Year	Institution	Code used in this thesis
1	The Global Competitiveness Report	2012	The World Economic Forum	GCR-12
2	Survey of ICT for Education in Asia and South Asia Countries	2010	InfoDev/ the World Bank	ICTEI-10
	Digital Review of Asia Pacific	2009 to 2010	International Development Research Centre	DRA-10
3	Survey of ICT for Education in Caribbean	2009	InfoDev/ the World Bank	ICTEC-09
4	Survey of ICT for Education in Africa	2007	InfoDev/ the World Bank	ICTEA-07
5	Various Country Study Reports and Case Study Working Papers in Argentina, Brazil, Kenya, Korea, Morocco, Nigeria, Philippines, Peru, Senegal, Sudan, Tunisia, Uganda, and Vietnam	2007 to 2012	InfoDev/ the World Bank	VCS-12

2.1.3 Finding in relation to developing countries

These surveys yielded five key findings in relation to education in same or connected regions. They were as follows:

1) Africa and Middle East

Surveys of ICT and Education in this region (Farrel, Isaacs, and Trucano 2007) revealed that progress being made in the adoption and diffusion of ICT in education throughout Africa, particularly in these early years of 21st century, is remarkable (Farrell, Isaacs, and Trucano, 2007: pp. 29). To keep the ICT adoption process continuing, seven suggestions were: 1) Monitor implementation, 2) Use ICT to achieve socio-economic development, 3) Provide a model for ICT in education with an appropriate budget, 4) Provide affordable ICT infrastructure for education, 5) Undertake teacher professional development

in regard to ICT, 6) In the Pan Pacific region, collaborate in the development of digital learning materials, and 7) Provide leadership so effective implementation of ICT in education in one region can foster other regions. The connection between regions, Africa, especially North Africa and the Middle East is not only cultural but also in some aspects are technological, wherein due to their geographic location, technology can be readily transferred between countries in these regions. Other surveys in Arab countries (Brisson and Kontiris, 2012) by InfoDev revealed that some countries in this region, particularly Tunisia, and Egypt are in the process of recovery from revolution and are developing new institutions. No data is available from Syria due to on-going political crisis, Libya due to administration problems and Angola due to lack of information (Schwab, 2012).

2) Latin America and the Caribbean

Surveys of ICT and Education in this region suggest that at the primary and secondary levels of education, the full potential of technology will only be unlocked by effective approaches to policy, internal and external forces affecting the Caribbean, and also addressing systemic challenges in Caribbean education. Through establishing the relevance of ICT and demonstrating it to be effective in the area of student learning, the Caribbean population will be able to link computer use to real-world productivity skills. In addition, the ability to access the dynamic sources of information on the World Wide Web and collaboration tools were proposed to be important for use in teaching and learning (Gaible, E., 2009, p. 55). Three points were identified as important for progressing ICT development in the Carribean: 1) Successful establishment of school-level ICT “infrastructure”, 2) Additional capacity for ICT related projects and 3) Improving impact from regional initiatives.

3) India and South Asia

Surveys of ICT and Education in this region revealed that access to ICT depends on three basic prerequisites: infrastructure, financial resources to meet the costs, and legal frameworks. While there may be little in terms of budget allocation for ICT infrastructure and facilities, internet access is available through wireless technology, wi-fi, and mobile telephony for some areas in this region. Excellent opportunities for minimizing the regional digital divide can be provided given the geographic, cultural, and economic regional complementarities in the South Asia region. In addition capacity building of the ICT resources was seen to ensure the availability and effectiveness of ICT-enabled educational interventions. Implementation of ICT requires financial support, and the costs for it are met by public funds from the national Governments and international funding agencies (InfoDev, 2010). One recommendation indicated that to maximize the effect of ICT on knowledge and growth, there needed to be maximum connectivity, provision of adequate network capacity and minimum required infrastructure (InfoDev, 2010). Further, it was recommended that appropriate technology for this region should be of the form of low-cost devices and budget PCs.

4) Asia (without India and South Asia Countries) and Pacific

Surveys of ICT and Education in this region revealed that Asia Pacific encompasses the most and least advanced countries as well as the least connected communities in the world (Purbo, 2009). ICT facilities such as wireless technology, wi-fi, and mobile telephony are currently available in this region. Low-cost devices and budget PCs were recommended as the appropriate technology for use in this region. There is also a SMART School Initiative in the Malaysian Education System, intended to prepare better students for adult life in a developing economy and to increase the flow of your people prepared for scientific and technological careers (Ong and Ruthven, 2010, pp. 25-41).

2.1.4 Major issues in ICT in developing countries

The Organization for Economic Co-operation and Development (OECD, 2000) addressed the differences in ICT between advanced economic countries and developing countries and concluded these are far more extensive than the use of the internet use as raised in Chapter 1. Major deficiencies, according to InfoDev (2007 to 2012) and the International Development Research Centre (2009) identified in developing countries, as explained in the result of surveys GCR-12, ICTEI-10, ICTEC-09, ICTEA-07, VCS-12, and DRA-09, which is include infrastructure, the education system, policy, lack of knowledge and skills, language, content diversity, readiness for technological uptake, level of school internet access, quality of mathematics and science education:

1) Infrastructure

Infrastructure related barriers and challenges are major problems for the implementation of ICT in education. The availability of telecommunication and information infrastructure, including the availability of electricity and telephony facilities for regions in developing countries is limited. Improvement of infrastructure is extremely costly. The development of ICT depends on actions of government, business and the education sector as represented in Figure 2.1 Governments are still working out that ICT education creates a better, more informed and more affluent society. ICT infrastructure in developing countries is limited due to lack of money spent by their respective governments. Educational organizations such as university, institutes, schools have realized the benefits of ICT not only in teaching and learning but also for the true wealth of the nation but they need government or business assistance. Developing countries such as India, have better infrastructure compared to other developing countries, that often have infrastructure costs affected by war or civil war. The lack of availability of electricity in some areas also becomes barrier to ICT infrastructure.

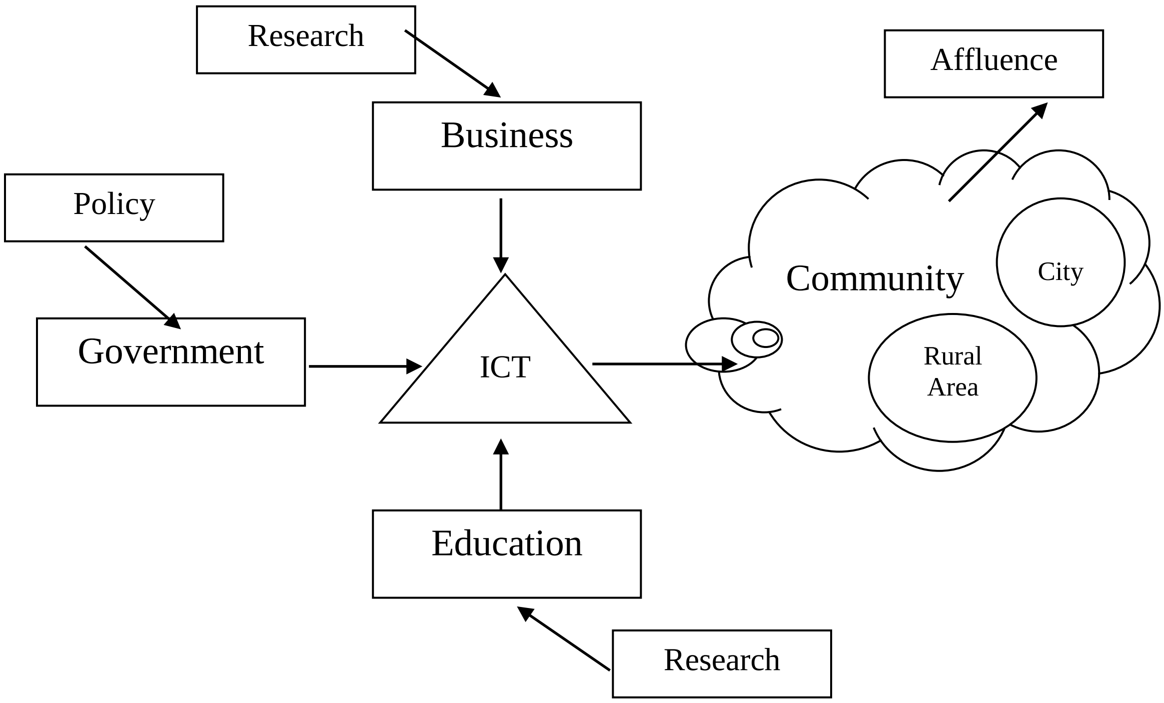


Figure 2.1 ICT and its stakeholders

In developing countries there is often a great disparity between city and rural areas in ICT infrastructure (just as there is in developed countries such as Australia). In the capitals, centres of business or big cities of many developing countries, computers and related equipment, but with limited, low quality internet connections, are available. However for rural or remote areas, and countries recently affected by war or civil war area there is a lack infrastructure compared to big and well known cities in developing countries.

2) Education system

The integration of ICT for use in teaching and learning is poor in the education systems in developing countries. To increase the awareness and take benefit

from the emergence of ICT, formal or national curriculum expects such integration. It is considered that since teachers who will teach in schools are usually generated from teacher institutes or teacher education programs, one approach to encourage the implementation of ICT is through the provision of, or introduction of, teachers and prospective teachers to useful technology tools.

3) Policy

ICT has spread quickly in developing countries and governments need ICT policies to manage it. However dedicated ICT policy in education policy is rarely available. The growth of ICT policy is usually for business or companies that normally impact on people or a large number of stakeholders, and rarely for schools or education purposes. To support the availability of the ICT policy dedicated to education these reports encourage developing countries to create joint policy between the ministries within countries, for example between ministry of education affair and ministry of technology affair in relation to education and ICT. Further, the reports recommend active ICT development support from schools and researchers, and the use of ICT related tools for education that can have impact on the community or large numbers of people. It is also already known that disparities in ICT in education policy and practices between developing countries is related to differences in their national context and corresponding ICT in education policies as well as their implementation period (Blignaut, Hinostroza, Els, and Brun, 2010, p. 1552).

4) Lack of knowledge and skills

There is lack of knowledge and skills in developing countries especially that relate to either recent advancement of technology (for example operating system development) or to high cost equipment (for example interactive blackboards or Access Grids). Many developing countries have no budget to buy ICT

commercial software and equipment essential to improve knowledge and skills in these countries. Interest in improving knowledge and skills in ICT is high but limitations in budgets become barriers for this activity. In some instances, interest in improving knowledge and skills in ICT accompanied by the challenges of low budget has lead to software piracy. To address this issue, many commercial companies, for example Microsoft Corporation provide special packages of their product with lower prices for people in developing countries.

5) Language

Developing countries often have multiple languages and hence need of teaching and learning resources in each language. This may pose difficulties for people learning when resources are created in languages other than their own. For some countries, such as Indonesia, many educated people and students (started in high schools), to broaden their perspectives are formally introduced and become familiar with an International language such as English. This means that in addition to their own language, for some developing countries, the use of English in ICT and education may be well accepted and as a consequence resources produced in English may be useful.

6) Content diversity

Developing countries in the world consist of many nations with different national viewpoints, different languages, and different cultures. This multiculturalism has lead to different curriculum purposes and different core education, resulting in content diversity as needed for each country. To reduce the diversity and acceptability in terms of the language of content is important with providers usually providing content in English and in plain single units that are flexible for use in different settings.

7) Readiness for technological uptake

Technological readiness is the ninth pillar in countries competitiveness (Schwab, 2012). This pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICTs) in daily activities and production processes for increased efficiency and enabling innovation for competitiveness (Schwab, 2012, p. 6). On average, developing countries' technological readiness scores over all regions are lower than the developed nations (refer Table 2.5).

Table 2.5 Comparison technological readiness scores

No	Type of Countries	Number of Countries	Average	Standard Deviation
1	Developed Countries	33	5.59	0.48
2	Developing Countries	120	3.37	0.78
	a. Africa and the Middle East	53	2.97	0.47
	b. Latin America and the Caribbean	36	3.79	0.63
	c. India and South Asia	8	2.90	0.36
	d. Asia Pacific (without India and South Asia)	23	3.80	1.03

Source of data: GCR-12

8) Levels of school internet access

Developing countries, regions of Africa and the Middle East, Latin America and the Caribbean, and India and South Asia, school internet access scores, measuring quantity and quality of internet access in schools are on average lower than those of developed countries (refer Table 2.6). The implication of this

is students in developing countries have less access available than those in developed countries.

Table 2.6 Comparison of developed and developing countries' internet access in schools scores

No	Area	Number of Countries	Average	Standard Deviation
1	Developed Countries	33	5.61	0.71
2	Developing Countries	120	3.48	1.11
	a. Africa and the Middle East	53	2.83	0.81
	b. Latin America and the Caribbean	36	3.87	0.90
	c. India and South Asia	8	3.38	0.59
	d. Asia Pacific (without India and South Asia)	23	4.47	1.13

Source of data: GCR-12

9) Quality of mathematics and science education

In developing countries in regions of Africa and the Middle East, Latin America, the Caribbean, and India and South Asia, the quality of mathematics and science education scores, are lower compared to developed countries (refer Table 2.7).

Table 2.7 Comparison of quality of mathematics and science education scores

No	Area	Number of Countries	Average	Standard Deviation
1	Developed Countries	33	4.82	0.76
2	Developing Countries	120	3.57	0.84
	a. Africa and the Middle East	53	3.41	0.64
	b. Latin America and the Caribbean	36	3.23	0.87
	c. India and South Asia	8	3.80	0.64
	d. Asia Pacific (without India and South Asia)	23	4.27	0.86

Source of data: GCR-12

Many of these issues identified as being present in developing nations also occur in Indonesia, the country that is the focus of this research. The following section discusses digital divide conditions as they relate to Indonesia.

2.1.5 Indonesian digital divide

Indonesia is one developing country located in the Asia Pacific region. The Asian Pacific region in terms of technological readiness, internet access in schools and quality of mathematics is ranked higher than the other developing nation regions (refer Tables 2.5 to 2.7). Although as displayed in Table 2.8 technological readiness, internet access in schools and the quality of mathematics education in Indonesia is neither the best of these developing countries ranking lower than Hong Kong nor South Korea, but not the worst, ranking higher than countries such as Thailand and the Philippines. The quality of mathematics education in Indonesia still is in need of improvement compared to other countries in this region such as South Korea and Malaysia and compared to the developed nations.

Table 2.8 Indonesia' term of development and ICT in Schools

Country	Terms of Development						ICT s in Schools	
	Technological Readiness (Score: 1 (very low) to 7 (very high))		Internet Access in Schools (Score: 1 (very limited) to 7 (extensive))		Quality of Mathematics and Science Education (Score: 1 (poor) to 7 (excellent))		Apprecia tion	Availabil ity
	Score	Rank*	Score	Rank	Score	Rank		
Hong Kong	6.2	4	6.0	16	5.4	11	High	High
South Korea	5.7	18	6.2	7	5.5	8	High	High
Taiwan	5.4	24	6.1	9	5.6	6	High	High
Malaysia	4.3	51	5.1	38	5.0	20	High	High
Brunei Darussalam	4.0	64	5.3	34	4.9	23	High	High
Kazakhstan	4.2	55	4.3	67	3.8	81	Low	Low
Mongolia	3.8	70	3.9	80	4.1	63	High	Low
Indonesia	**3.6**	**85**	**4.5**	**56**	**4.4**	**45**	**High**	**Low**
Thailand	3.6	84	4.3	63	4.1	61	High	Low
Philippines	3.6	79	4.1	73	3.6	98	High	Low
China	3.5	88	5.4	31	4.6	33	High	Low
Vietnam	3.3	98	5.0	41	4.1	58	High	Low
Cambodia	3.3	100	3.8	83	3.7	90	High	Low
Iran	3.1	111	2.9	117	4.6	32	High	Low
Tajikistan	3.0	114	3.6	94	3.7	91	Low	Low
Kyrgyzstan	2.6	130	3.1	114	3.1	114	Low	Low
Timor-Leste	2.6	131	2.4	128	2.4	136	Low	Low
North Korea	-	-	-	-	-	-	High	Low
Lao PDR	-	-	-	-	-	-	High	Low
Myanmar	-	-	-	-	-	-	High	Low
Macau	-	-	-	-	-	-	High	Low
Turkmenistan	-	-	-	-	-	-	Low	Low
Uzbekistan	-	-	-	-	-	-	Low	Low

* List of countries in this region is shorted based on the countries' technological readiness score world ranking (Schwab, 2012)

Furthermore, the findings from the InfoDev surveys show that Indonesia, the site for the work in this thesis, is a country that is likely to benefit from developments that help reduce the digital divide or the gulf between those who have ready access to ICT computer and the internet and those who do not (OECD, 2000). Bridging this digital gap in ICT, is a priority for both the economic and social development in developing countries (OECD, 2000: 3). Indonesia also experiences deficiencies including deficiencies in ICT infrastructure, facilities and resources for teaching and learning.

The disparities between developing countries and developed, and even disparities within developing countries encouraged the researcher to investigate the potential that ICT can offer many developing countries, and in particular, the possibilities from using dynamic sources of information on the World Wide Web. In this thesis the developing nation of interest is Indonesia but the expectation is that the ICT developed would suit other developing countries at least in the same Asia Pacific region.

2.1.6 ICT initiatives and implementation in education

Survey reports from IndoDev (2007, 2009, and 2010) also address current usage of ICT in primary, secondary and tertiary schools and pre-service and in-service teaching professional development from these countries. Some sections of the reports briefly discuss regional and global trends of ICT in education and selected regional ICT initiatives and projects in education. In terms of this thesis, studies by InfoDev (2007, 2009, and 2010) briefly report on the availability of ICT in school education, monitoring and evaluation of ICT in education, knowledge map: ICT in education, and ICT initiatives and projects.

1) ICT in school education (primary and secondary)

InfoDev (2010) revealed that in developing countries, new and emerging technologies, such as internet and computer are being integrated with the older technologies, such as blackboard and overhead projector in school education. In addition, there has been progress in the development of systems in secondary schools that for example standardize the development of resources, cataloguing them, and storing them. These resources include learning objects, which are digital Web-based resources created to support learning and can function as discrete entities or be linked in order to relate to explicit concepts or learning outcomes (InfoDev, 2010, p.2).

2) Monitoring and evaluation of ICT in education.

According to the InfoDev report (2007), the committed involvement of professionals is required for any systemic change, large or small, but that the large majority of the instructional staff in the current educational systems remains with little or no ICT literacy and therefore limit the potential for change in ICT in education.

3) Knowledge maps: ICT in education

Knowledge maps are outlines provided by InfoDev to determine what is known and what is not known about the use of ICT in education. These knowledge maps reveal that despite a decade of high investment in ICT with aims to benefit education in developing countries, and to increase use of ICT in education in developing countries, there are important gaps in improving education (Farrell, Isaacs, and Trucano, 2007).

The knowledge maps reveal the impact, cost, current implementation of ICT in education, and policy. According to the maps, the impact of ICT in education is still an open debate, with a gap between the rationale, most often presented to advance the use of ICT in education, and its practical implementation. There is growing interest in the use of ICT in education, even in the most challenging environments in developing countries, but best practice and lessons learned about ICT in education have not been widely disseminated nor packaged into formats easily accessible to policy makers in developing countries which inhibit ICT growth in education (Farrell, Isaacs, and Trucano, 2007).

4) ICT initiatives and projects

Many major, well known, and reported ICT initiatives or projects with regard to different aspects of ICT have been implemented in education in developing countries. These initiatives when considered in terms of what has happened and when it has happened in developed compared to developing countries assists in understanding the nature of the digital divide in developing countries. The initiatives can be classified in term of outcomes in relation to technology, education, learning management system, or theoretical frameworks.

With respect to the use of ICT technology, there is specialist software has been developed (see examples in Table 2.9) to create or facilitate educational activities and to solve problems related to education in some developing countries. The software developed is intended to appropriate for use that is usable given current ICT conditions where the technology is to be applied.

Table 2.9 Technology initiatives to address the digital divide

Characteristics	**Selected or Major Initiatives – Technology Development**
Development of technology for teaching and learning for use in developing countries	1. The iEARN Project helps collaboration of children and your adult on school assignments using the internet or other communication technologies (iEARN, 2012) 2. Web server that enable students to use the expensive laboratory equipment virtually (Gonzales, 2006) 3. EDUWEBTV in Malaysia (Bower, 2010) 4. IMMEDIATE, software that provides a specialized e-learning environment for the PC which is more accessible and usable for students (Johnsons, Kemp, Kemp, and Blakey, 2006). 5. PROTEGE QV E-learning promoted technologies that guarantee environment and a better quality of life (Global Knowledge Partnership, 2005) 6. EDUTECH 2000 prioritizes the transformation of teaching and learning through curriculum reform, and new assessment (Ministry of Education, Barbados, 2000)

Other software has been introduced for use in developing countries to facilitate the management of learning (refer Table 2.10). Several initiatives in learning management also involves sponsors, either commercial for example Microsoft

and Intel and non-commercial sponsors (refer Table 2.11). Software providers often promote their product for use in the initiative, with commercialisation in the later stages of implementation; however there are still benefits important for people in developing countries that occur through these programs.

Table 2.10 Learning management initiatives to address the digital divide (continue)

Characteristics	Selected or Major Initiative – Learning Management
Specific learning management for developing countries	1. SchoolNet to promote access to satellite television and video to access education channels such as Mindset Learn, Discovery Channels, and National Geographics. (2012) 2. Introduction of open courseware in South Africa (Sanga, 2006) 3. African Virtual University (10 African countries and African development Bank, 2010). 4. National Qualification Register (NQR) and Learning Management System to solidify the relationship between education, training, and employment in Jamaica (HEART TRUST, 2008) 5. On-line distance learning in India (Khan, 2000)

Table 2.11 Learning management initiatives to address the digital divide (continue)

Characteristics	Selected or Major Initiative – Education
Introduction or implementation of technology for education in developing countries	1. College IT Enhancement Programme (VVOB, 2012) 2. Education support network project (OneWorld Africa, 2012) 3. Network Alliance Project to strengthen the use of email and internet (NGO and civil society organization, 2012) 4. World Links to encourage access to ICT in rural areas (World Links, 2012) 5. Intel Teach Program provides in-service and pre-service teachers integrate technology in classroom (Intel Corporation, 2008) 6. Microsoft – “Project Shiksha” in India. Instils ICT skills required to enhance the teaching and learning process (Microsoft, 2008) 7. NEPAD e-schools that aims to ensure that all schools on the Africa are equipped with ICT facilities with teachers trained to using them (e-Africa Commission, 2007) 8. E-Learning implemented in Uganda (Bada, 2006) 9. Technology use in schools in Botswana (Batane, 2006) 10. Introduction of ICT at schools in China (Zhang, 2003) 11. The use of internet resources in Colombia (Mosquera, 2001) 12. Educational Satellite Channels in Egypt provides multimedia films and mobile technologies (The Centre for Technological Development and Decision-Making Support, 1998)

Lastly, some researchers take contribute through developing theoretical frameworks (Table 2.12), or undertaking literature reviews and discussion on how technology, in particular ICT could be of benefit for developing countries. Through their works, visions of ICT implementation are clearer and public awareness of the new idea is raised.

Table 2.12 Theoretical frameworks to address the digital divide (continue)

Characteristics	**Theoretical frameworks or building knowledge**
Discussion or recommendations in regard to ICT for education in developing countries	1. Guidelines developed for online courses in Oman (Hall, 2009), 2. Identifying computer related technology recommending as suitable for use in developing countries (Beynon, 2006) 3. Characterised the current conditions for teaching mathematics in primary schools Zimbabwe (Mtetwa, 2005)

2.2 Learning Theory

Learning is part of human life, and currently conducted by people in both developed and developing countries. Through learning people develop themselves by learning new knowledge and skills to improve their productivity. The collective productivity of people in some countries will lead to the improvement of country in which they live. Learning as a process and what it entails is examined and explained by many broad theoretical perspectives. Although there are differences between the theories about the term learning, it is widely accepted that three domains cognitive, affective, and psychomotor are related to the learning process.

According to Eggen and Kauchak (2004, pp. 465-467), the cognitive domain is the learning domain that focuses on the cognitive processes involved in learning different forms of knowledge, the affective domain is the learning domain that

focuses on the development of student affective side caused by learning process, while the psychomotor domain is the learning domain that focuses on the development of students' physical ability and skills. Similar areas are proposed by Bloom known as areas of cognition, affect and manipulative or motor-skill development, although the psychomotor domain was not considered of immediate importance and hence the development of this part of taxonomy was deferred (Morris, 2008). However, the psychomotor domain, in Bloom‘s taxonomy considered to involve manipulative or motor-skill development is important for students in learning mathematics, for example to sketch a graph of function either using pencil and ruler or computer, is considered in this research.

In Indonesia, formal teaching and learning processes at elementary and secondary schools are coordinated and dominated by teachers. In Indonesia, teachers are trained in conventional ways, however implementation of technology, such as Online Learning Community has been introduced and implemented with a view to transforming the teaching and learning process. This transformation is to be enacted through facilitating interactions between teachers aimed at improving their professional practices. Interaction and how teachers learn or follow others is important in this practice.

Learning must encompass the practical as well as the intellectual to improve someone's "know-what", know-how", and "know-why (Marcum, 2002, pp. 11-12). Broadly speaking through learning people change their behaviour, improve their knowledge, and adapt to their environment, however there are different views as to what learning entails depending upon different theoretical perspectives such as behaviourism, social cognitive theory, cognitive learning theory, constructivist learning theory and resource based learning.

2.2.1 Behaviourism

Learning, in the view of behaviourism (Eggen and Kauchak, 2004, p. 196) is a relatively enduring change in observable behaviour that occurs as a result of

experience. Behaviourism focused on observable behaviours and did not consider ideas, insights, goals, or needs of the learner. From this theoretical perspective there are three type of learning: 1) Contiguity, learning due to a simple stimulus and response, for example, drill and practice in arithmetic, 2) Classical conditioning, learning due to emotional and physiological responses to stimuli, for example, a student failing an algebra quiz then may become anxious during their next algebra quiz, and 3) Operant conditioning, learning due to behavioural changes that result from consequences (reinforcement or punishment), for example, a student attempts to answer a question and is praised, so future attempts will be increase

2.2.2 Social cognitive theory

Social learning theory as for behaviourism considers learning to be a relatively enduring change in observable behaviour that occurs as a result of experience. Social cognitive theory considers condition in which people learn from observing others and gradually control their own behaviour. For example a student learns how to solve an equation after the teacher shows how the procedure (Eggen and Kauchak, 2004, p. 196-213). When the cognitive social theory explains learning by focusing on changes in mental processes and structures that occurs as a result of people's effort to make sense of the world there is a shift to the term cognitive learning theory.

2.2.3 Cognitive learning theory

Beside the observable behaviour, as explained by behaviourism and cognitive social theory, the process of learning also can be viewed by cognitive social theory as mental processes which people use to make sense of their world, answer questions, and solve problems. This theory is grounded in four basic principles:

- *Learners are active in their attempt to understand their experiences.*
- *The understanding that learners develop depends on what they already know.*

- *Learner construct, rather than record, understanding.*
- *Learning is a change in a person's mental structures.*

(Eggen and Kauchack, 2004, p. 237)

2.2.4 Constructivist theory

The basis of constructivist theory is that learner constructs understanding, rather than having that understanding transmitted to them by some other source such as another person or something they have read (Eggen and Kauchack, 2004, p. 280). There are four basic characteristics of constructivism: 1) Learners construct understanding that makes sense to them, 2) New learning depends on current understanding, 3) Social interactions facilitates learning, and 4) The most meaningful learning occurs within real-world tasks (Eggen and Kauchack, 2004, p. 283). Due to these characteristic, several suggestions for teaching have been raised: 1) Provide learners with a variety of examples and representations of content, 2) Connect content to the real world, 3) Be sceptical about the effectiveness of explanation, and 4) Promote high levels of interactions. In practice, the process of learning itself, according to Cjaza and Sharit (2013, pp. 44-51) can be achieved through three stages. The first stage involves identifying and trying to discriminate and understand various stimuli, facts, and basic concept and making associations between mostly concrete stimuli. The second stage is formation of schemas in the form of rules and other types of associated knowledge. It involves the movement from surface features of knowledge to task-specific knowledge. The third stage involves automation of basic rules, development of higher order rule forms and greater ability to discriminate among facts and concepts.

In order to make sense of the real world, as suggested by constructivism, information literacy is needed. One of the relevant learning methods to information literacy is resource-based learning. As suggested by Haycock (2006, p. 50) information literacy in its fullest form requires some classroom teachers to move from a behaviourist, skills and drills methodology to a constructivist, resource-based learning methodology.

2.2.5 Resource-based learning

Through the emergence of recent ICT developments, in particular internet technology, web resources have emerged. Web resources can be interactive learning resources (Ndahi, Charturvedi, Akan, Vickering, 2007, pp. 9-14) or as static web resources (Moen, Nygaard, Gauperaa, 2009, pp. 520-533) but still useful for providing people with the opportunity to train and develop competency. This availability of resources facilitates what is known as resource based- learning.

> *The concept of resources-based learning always involves an active learner confronting a learning resource or set of resources. Students independently might make decisions about problem solving or they might follow steps determined by the teachers to locate specific information. Resource based learning is the process by which students acquire these information handling skills: managing and using information to solve problems, interrelating knowledge, and effectively communicating learning outcomes.*
>
> *(Bleakley and Carrigan, 1994, p. 4).*

The key for resource based learning as described is the resources themselves that may be available which can be used by the learner to construct understanding. The skilful manipulation of sources of information is an essential facet of resource-based learning (Bleakley and Carrigan, 1994, p.5), and mapping and managing knowledge and information is important in this process (Tergan, Graber, and Neumann (2006)). Resource-based learning in learning theory, advocates teaching how to learn, not what to learn, and is the antithesis of the textbook, teacher/lecturer method of instruction (Thomas, 1999, p. 26) as such, information literacy and the development of this is an important outcome from this type of learning.

There is a five-pronged process for achieving information literacy:

1. *Students first identify the kind of information needed to address a specific problem.*
2. *Then, they locate and access the information.*
3. *Then analyse and evaluate the content.*

4. *They decide how to use the information and organize it appropriately.*
5. *Finally, students effectively communicate the outcomes*

(Bleakley and Carrigan, 1994, p. 5)

If resource-based learning develops information literacy, then the information literate student will able to use resources for extended [length of life] learning (Bleakley and Carrigan, 1994, p. 4). Although as argued by Marcum (2002, p11) while information literacy acknowledges the purpose of improving the learning process, as an outcome the term is too broad and must clarified to provide realistic objectives (2002, p11). Regardless, much research has provided empirical evidence of the advantages of resource-based learning. Many authors discuss the advantages of having resources accessible via the internet. Such resources have the potential to support resource-based learning, as follows:

> *Technology has introduced a new dimension in resources-based learning [through] the opportunities for flexibility in time and place offered by delivery of course material either through CD-ROM or the World Wide Web (WWW), and [along with] the potential for access to a wide variety of diverse information sources in resource-based learning.*
> *(Macdonald, Mason, Heap (1999, p. 345))*

> *As ICT resources are playing an increasingly important role in teaching and learning, ..., it is vital that practical solutions are developed to ensure that all children have an equal opportunity to learn and to achieve*
> (McNicol, Nankivel, Ghelani (2002, p. 401)

Advantages linked to resource based learning include: familiarizing and supporting teachers in implementing “Discovering Democracy” materials (Murray, 2003, pp. 20-22); fostering discipline inquiry with best-served students through collaboration between students, teachers and teacher-librarians (Haycock, 2006, p.33) and,; effectively supporting the management of knowledge and information, for example through using ICT based mind mapping tools (Tergan, Graber, Neumann, 2006, pp. 327-336). Positive comments regarding resource-based learning suggest that the learning experience are much better than conventional learning but this accompanied

by negative comments that suggest less able students through this methods fail to grasp the meaning of essential and basic materials (Fry, Pearce, and Bright, 2007, pp. 79-91). The availability of resource accessibility via the internet is seen to be a huge benefit for developing countries as the main problem is only internet connection and computer condition to access it.

Researchers have also identified a number of disadvantages associated with resource-based learning; 1) The process of searching resources is long and costly (Ryan, Wells, Freeman, Hallam, 1996, pp. 93-98); 2) The circumstances in and beyond schools may disadvantage students without easy access to resources and 3) A child's school, home, and locality all have significant impacts on their access to ICT resources (McNicol, Nankivel, Ghelani, 2002, pp. 393-401). Indeed the discrepancy between the *haves* and the *have nots* in terms of technology is at the core of the digital divide an issue which this project seeks to address. When searching for ways to reduce the digital divide in education one search is for ways to use ICT in Education. According to Pierson (2001, p. 427) there is relationship between resources as contents of subjects, and pedagogical and technological knowledge to know what to do with these resources as illustrated in Figure 2.2. Implication of this is the pedagogical aspect with technology is also need to be taken into account, not just the resources itself.

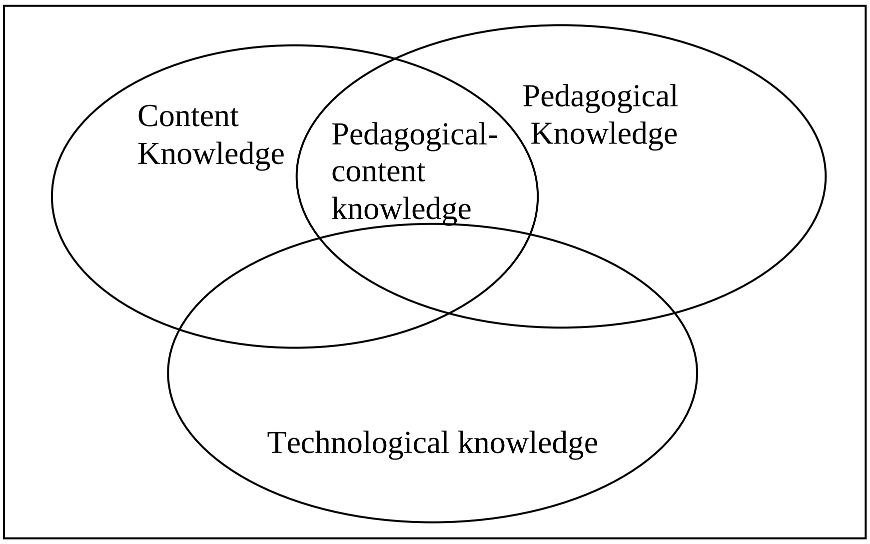


Figure 2.2 Relationships among resource, pedagogical, and technological knowledge (adapted from Pierson (2001, p. 427)

Allen (1996) initiated a discussion of teaching with technology, while Oldknow and Taylor (2000, pp. 3-9) suggest four contexts for ICT in education: 1) teachers' use of ICT to help plan, prepare and manage teaching, 2) individual pupils' use of ICT outside normal lessons, 3) pupils and groups of pupils using ICT within a lesson, and 4) teachers using ICT with a whole class. In accordance with this suggestion, mathematics teachers not only can provide resources accessible via the internet for use in resource based learning but also can use ICT technology to help plan, prepare and manage teaching both areas for increased participation by teachers with ICT in developing countries. Following these thoughts regarding the use of resources in learning, to address the digital divide the researcher for this thesis sought to identify what technology was available, what teachers wanted by way of assistance and explored how the existing technology could be utilised to impact on mathematics education. The focus became finding ways to map mathematical learning resources and learning designs and to share those via the internet.

2.3 Mathematics education

In bridging the digital divide, as it relates to improving mathematics education through supporting learners to construct understanding of mathematics, two areas, identified through initial observations and discussions with teachers, of primary interest are: 1) The use of mathematics learning resources, and 2) The development, use and sharing of learning designs. The use of technology, especially Information and Communication Technology (ICT) is important conduit for mathematics teachers since it spreads quickly and influences mathematics teaching and learning practice. The emergence of ICT offers the possibility of making mathematics teaching and learning practices more effective and efficient, and for these reasons; technology should be considered in teaching and learning mathematics (Forster, 2006). Mathematics teachers are important components in the institutionalization of mathematics, especially in promoting the spread of mathematics knowledge to the

community. Teachers take knowledge and skills from their education in universities to the schools where they teach. To be able to effectively integrate technology into mathematics teaching, it is important that teachers gain such technological skills. The implementation of technology-based mathematics teaching and learning is dependent upon the availability of ICT.

When considering mathematics education in developing countries two priorities identified by English (2008) are pertinent to this thesis. The first priority is the need to create life-long democratic access to the powerful ideas of mathematics. This is consistent with the notion of access to resources and ideas by people all over the world, either in developed or developing countries. The second priority emphasizes the need to consider the influences of advanced technologies in mathematics teaching and learning, while noting that designing high quality, technology-supported learning experiences and exposure are significant challenges for educators (Lockyer, Bennett, Agostinho, and Harper, 2009).

In seeking to explore the use of internet based learning resources for mathematics it seemed pertinent to examine what constitutes a resource, the role of these resources in mathematics education and examine more closely the types of resources currently available.

2.3.1 Mathematical learning resources

Mathematical learning resources as defined by the Ministry of National Education, Canada (1999) is as follows:

> *Learning resources are defined as information, represented and stored in a variety of media and format that assist student learning as defined by provincial or local curricula. This includes but is not limited to, materials in print, video, and software formats, as well as combinations of these formats intended for use by teachers and students (available at:*
> www.bced.gov.bc.ca/irp/welcome.php)

In this thesis, mathematical learning resources draws on these ideas, and is defined as sources of information, represented in a variety of media and format that can be used to assist student learning through study, experience, or being taught, as defined in national curricula, for the acquisition of knowledge or skills related to mathematics. Some resources are available as documents (such as text, html, and pdf), audio and video (such as movie, music), and other electronic types of resources such as flash animation, interactive JavaScript, and applications. In addition to the term of learning resource, several researchers proposed the term learning object as part of teaching and learning. According to Cisco System (2001) in Churchill and Hedberg (2009), the idea behind learning objects was that the curriculum content of a course could be broken down into small, reusable instructional components and each one addressed a specific learning objective. Mathematical learning resources can be considered as learning objects when formed in a single unit reusable for other learning activities. Mathematics is mostly sequential building on gains in knowledge or skills.

When addressing the digital divide several ideas in relation to mathematical resources are important:

- students, primary, secondary and tertiary, need to have access to ideas and concepts of mathematics that are embedded in mathematical learning resources (Langrall, Mooney, Nisbet, & Jones, 2008; Rojano, 2008; Mamona-downs & Downs, 2008);
- classroom practices including the provision of meaningful access to mathematical learning resources within the classroom promotes motivation Walshaw and Brown (2012); and
- classroom practices, which cater to students’ individual differences in choosing optional mathematical learning resources is related to students academic achievement (Inglis, Palipana, and Ward (2011))

2.3.2 Organisation of learning resources for teachers

The rise of information and communication technology has enabled mathematical learning resources to be available on the internet. The uses of these resources are many and varied and they can be organised in different ways. Ameis (2006) in his book Mathematics on the internet briefly describes the use of resource materials and information available on the internet for teaching mathematics.

> *The internet can play an important role as a spark for changing and shaping students' opportunities for learning mathematics. In that regard, this book helps teacher educators, college students preparing to become mathematics teachers, and teachers in elementary, middle, and high schools to become better acquainted with some of the resource materials and information available on the internet for teaching mathematics. (Ameis, 2006: p. v)*

Ameis (2006, p. 30-120) provided many hyperlinks to mathematics teaching resources. The resources include mathematics teaching resources and professional development resources, as a substantial guidance for teachers to enable teachers and students locate these resources easily. Kissane (2006) also provided links to a range of mathematical learning resources for teacher use on the internet Kissane (2006) to directly assist teachers find lessons plans, access professional development and receive information of educational affairs in their area classified and linked to resources according to teacher use (refer Table 2.13).

Table 2.13 Classification of internet resources for teachers

Direct lesson materials or ideas	Web sites that suggest idea to teachers for lessons and classroom tasks
Official communications regarding the curriculum or the governance of education within their environment	Web sites provided by authorities to provide both guidance and support to teachers undertaking their mandatory roles.
Professional engagement	Web sites managed by professional association of mathematics teachers.
Commercial element, yet still opportunities that were previously inaccessible.	Web sites that offer significant support of various kinds to a professional client base
Local use within a school or school district	The use of schools web site for teaching purposes in class or by local District

(Source: Kissane, 2006)

2.3.3 Organisation of learning resources for students

According to Liu (2005) quality of web resources from different domains (com, org, edu, and gov) and different designers (professional, college student, teachers, and university professors) are different. Cennamo, Ross, Ertmer, (2010, pp. 105-107) also reminds us that anyone can publish on the web through personal or organizational websites, postings on message boards, blogs. Wikis, and more. For these reasons it is particularly important that students learn how to verify the legitimacy of content on the internet. Following is Cennamo, Ross, Ertmer's, (2010) suggestions regarding evaluating web resources:

Table 2.13 Evaluating web-based resources

Who is responsible for the information resource? • The name of author(s) is evident. • The author's authority, credentials, background, and/or expertise are clearly stated. • The site includes background information for the author(s), such as previous works, publications, affiliations, etc. • The name of any sponsoring institution or organization is included, along with a current link to that organization. • The relation between the author(s) and the sponsoring organization is specified.	**When was the information published?** • The information is current, including original date of the document and latest update. • Linked information is up to date; links are active **Why is the resource published?** • The purpose of the resource is clear and its content reflects that purpose, whether it is to inform, persuade, entertain, or sell. • Informative or entertaining resources are free from bias. Persuasive or sales sites are easily identifiable.
What about the content? • The resource provides thorough information that adequately meets the information need. • The title of the resource clearly conveys its content. • The source for information is documented; links to the source are included • The content is free from spelling and grammatical errors.	**How useful is the resource?** • Information is presented clearly at the level appropriate to the target audience. • The resource is logically organized and easy to navigate, including a search box and/or site map if the resource is large.

Source: Evaluating Web Resources. Cennamo, Ross, Ertmer, (2010, pp. 105-107)

Resources can be used by people to teach topics related to these resources but also for students to learn from them. Perhaps the desire to provide students with verified resources has been the motivation for educators to structure and fill their sites with verified materials, originally for their own students. Kissane (2006) structured resources into six areas for student learning (refer Table 2.14).

Table 2.14 Classification of internet resources for students

Students	
Interactive Resources	Resources that taking advantages of the possibility of designing web objects that students can manipulate directly, using software platform such as java and flash.
Worthwhile reading materials for students	Well-written materials in several of forms, which have become accessible to students through the internet.
References materials	Dictionaries, encyclopaedias, and databases of mathematically related materials.
Communication	Web-based communications related to mathematics between students and others.
Problem solving	Web sites that offer regular problems and puzzles for students of different levels of sophistication, as well as advice and hint on solving them
Web quest	Structured explorations of situation of mathematical interest

(Source: Kissane, 2006)

The mathematics learning site "Summertime Maths" has been used to provide refreshers resources to students making the transition from highschool to university. This is an example of a mathematics learning module with open access to students (http://www.math.uow.edu.au/subjects/summer/subjects/m151.html). For a range of topics 'Summertime Maths" provides students with structured review materials in the form of worked examples, theory refreshers, using a variety of media, print and video to appeal to the various learning styles and capabilities of students. With a view to reducing failure rates alternative provisions of resources combining audio and visual components ,has been used as embedded learning support across all topics in a tertiary Mathematics subject (Aminifar, Porter, Caladine, and Nelson (2006)).

There is evidence that the availability of resources in itself is not sufficient to improve learning outcomes. According to Calverley and Shephard (2003, p.205-224) good learning resources are not enough because of its low uptake. There is a need to match resources available to the identified need of users and to their perceived

expectations. In addition, consideration needs to be given to how those resources are combined in some form of learning design (Baharun, 2012).

2.3.4 Learning designs

Learning is defined as the acquisition of knowledge or skills through study, experience, or being taught (Oxford Dictionaries), and design is defined as purposes or planning that exist behind an action, fact, or object (Oxford Dictionaries). Based on these definitions, learning design is the planning that exists behind actions or facts of the acquisition process of knowledge and skills through study or experience.

Learning design can be considered in two ways: 1) As a process designing learning experiences and (2) As a product, that is, the outcome or artefact of the design process (Agostinho, 2009, p. 4). The purpose of learning designs is to document and describe learning activities that other teachers can understand and use (in some way) in their own context (Donald, 2009, p. 2). The central theme of Koper and Tattersall' book (2005) Learning Design: a Handbook on Modelling and Delivering Networked Education and Training is that learning designs, as a process designing learning experiences, can be used to model and circulate the teaching and learning experience in education and training

According to Agostinho, Bennett, Lockyer, and Harper (2011, p. 92) the term learning design refers to research and development dedicated to the quest of equipping teachers with tools and strategies to aid their design of high-quality learning environments. Learning environments are related to learning experiences and if effective teaching and learning practices can be represented in a systematic way, this could then support the process of reuse, which could ultimately lead to improved practice and hence the notion of learning design to communicate these teaching and learning practices (Agostinho, Bennett, Lockyer, and Harper, 2011, p. 97). In relation to the future of learning design, Agostinho, Bennet, Lockey, and Harper (2011, p. 97) stated as following

> *More empirical research is needed to better understand teachers' design practices so that closer alignment between teachers' needs and learning design initiatives can be achieved.*
> *(Agostinho, Bennet, Lockey, and Harper, 2011, p. 99)*

Another type of technology is the WebQuest, an organized resource for presenting lessons (Cennamo, Ross, Ertmer, 2010, p. 86). A typical WebQuest contains instructional components elements:

- *An introduction that motivates and prepares students for the activity;*
- *A clear statement of the intended outcomes of the lesson;*
- *The steps that students should follow*
- *Criteria on which they will be evaluated; and*
- *Concluding activities where students reflect on and extend their learning.*

(Cennamo, Ross, Ertmer, 2010, p. 86).

Doll (2009, p. 18) found the revision of the learning design process is essential for improvement, stating that successful teachers continually practice, evaluate, refine, and reflect on their teaching and context in order to improve. The three steps planning the design of learning included the setting of goals and objectives, deciding how to teach the lesson, and the thirdly the location or creation of materials (Doll, 2009, p. 19).

The use of learning designs is predominantly undertaken in developing countries where educationists know their purpose and use. The term itself is gaining momentum in the e-learning literature. In Indonesia, the term learning design is beginning to be popularized through for example the First South East Asia Design/Development Research Conference that has one of its foci on learning designs (held in Palembang, Indonesia 20-21 April 2013). The conference disseminated the knowledge of learning designs by invited speakers from Utrecht

University, Netherlands and National Institute of Education, Singapore as well as local speakers from Sriwijaya University and the Indonesia University of Education.

Awareness of learning designs, their applicability, and usefulness together with the documentation and sharing of learning designs as appropriate tools and procedures is important for such developing countries, however in terms of use of learning designs in developing countries it is important to remember that there are inherently different conditions, particular in regard to ICT.

2.3.5 Learning designs tools

According to Agostinho (2009) 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), LDLite, and Patterns. Following comparison of these learning design representations, Agostinho, (2009), indicated most learning designs deal with online activities or implement online platforms. To facilitate the implementation of learning designs, tools to represent and media to document and share teaching practice have been developed, as detailed in Table 2.15.

In addition to learning designs tools, Sicilia, Lytras, Sanchez-Alonzo, Garcia-Barriocanal, and Zapata-Ros (2011) have tools to model instructional-design theories to check, generate, and search available learning design tools or documentations. Boyle (2010) proposed tools on layered learning designs, in which learning design and learning objects are integrated. According to Boyle (2010, p. 661) the use of ICT to enhance teaching and learning depends on effective design, and learning objects (learning resources) should be viewed as instances of learning designs, in a combined reference model where there is a correspondence between learning designs and learning objects types at each layer (Boyle, 2011, p. 661).

In the following chapter the methodology used to ascertain ways to elucidate ICT conditions in Indonesia and to determine how best to work with Indonesian teachers

to develop the use of ICT in mathematics education is discussed. Resource based teaching and learning designs were two areas confirmed as being of importance.

Table 2.15 List of available learning design tools

No	Name of Tool	Developer	Cost	Feature(s)	Review
1	Educational Environment Modeling Language (E2ML)	Luca Botturi	Private ownership/ unknown	Documents an educational environment (entire course, subject, and one or more activities)	This Learning Design is currently being used in large collaborative projects in Swiss universities according to (Botturi, 2006) in (Agostinho, 2009, p. 5).
2	IMS Learning Design (IMS LD)	Originally developed at Open University of the Netherland. The specification is maintained by the IMS Global Learning Consortium.	For use by IMS members	Documents contextualized teaching and learning, and enables online courses to be shared and reused.	This learning design tool is widely used and accepted a standard of learning design representation.
3	Learning Activity Management System (LAMS)	LAMS Foundation	GPL v.2 (Freedom to end users to use, study, share (copy), and modify the software)	Visual authoring environment	This learning design tool can be used to design, manage and deliver online collaborative learning activities. It provides teachers with an intuitive visual authoring environment for creating sequences of learning activities. LAMS is being used in many universities and schools in Australia, New Zealand, UK, and China.
4	Learning Design Visual Sequence (LDVS)	Agostinho, Harper, Oliver, Hedberg, & Wills	Private ownership/ unknown	Documents a learning design visually by illustrating the chronology of tasks, resources and supports using symbols for each of the three learning design elements (squares/rectangles for tasks, triangles for resources and circles for supports).	LDVS is being developed between Australian Learning Management and Open University of the Netherland.
5	LDLite		Private ownership/ unknown	Provides support for teachers to design blended activities, integrating face-to-face and online activities	Considered as new learning design tool by Agostinho (2008).
6	Patterns		-	Documents successful solutions to a recurring design problem and the solution can be reused or replicated in many different contexts	There is not a lot of use Patterns by teachers (Falconer and Littlejohn, 2006) in (Agostinho, 2009, p. 5)

7	CompendiumLD	Open University of the Netherland		Predefined sets of icons, some generic and some specific to learning design. Users can add captions to each icon. Most common types of electronic files can be copied and pasted in to the design (including word documents, Powerpoint presentations, images, pdfs) enabling it to become a repository for building resource collections.	A visualisation tool for designing learning activities. CompendiumLD is a type of mind mapping or concept mapping tool that can be used to design a learning activity that provides a default set of icons for creating maps to visualise the connections between ideas.
8	Phoebe	University of Oxford	Under development	Not available	Web application that acted as learning designs tool.
9	Learning Design Support Environment (LDSE)	Elizabeth Masterman	Private Ownership	The feature include forms of representation of learning designs, an ontology for learning design, designing at Module and Session levels, Importing and adapting an existing design, Selecting from existing teaching-learning activities. Editing the properties of TLAs. Extensive advice and guidance. Analysis of teaching costs and learning benefits. Sharing specific and generic patterns. Exporting a design to an institutional format.	

CHAPTER 3. METHODOLOGY

This chapter is framed in terms of justifying the method selected and used in this research. It discusses issues in selecting method; the research method chosen, and explains the rationale and process behind the four phases of research that includes: 1) localised investigation: identification of ICT conditions, 2) development of software tools, 3) implementation, and 4) evaluation of innovations using Alexander and Hedberg's model.

3.1 Issues in selecting method

Many research designs are available for conducting research related to the development of technology-based tools for use in developing countries. Choices for research design include qualitative, quantitative, and mixed methodologies. According to Creswell (2009, p. 3) research designs are plans and the procedures for research that span the decision from broad assumptions to detailed methods of data collection and analysis. In the process of selecting an appropriate research design, the philosophical world view associated with the selected strategies of inquiry and research methods as represented in Figure 3.1 needs to be addressed.

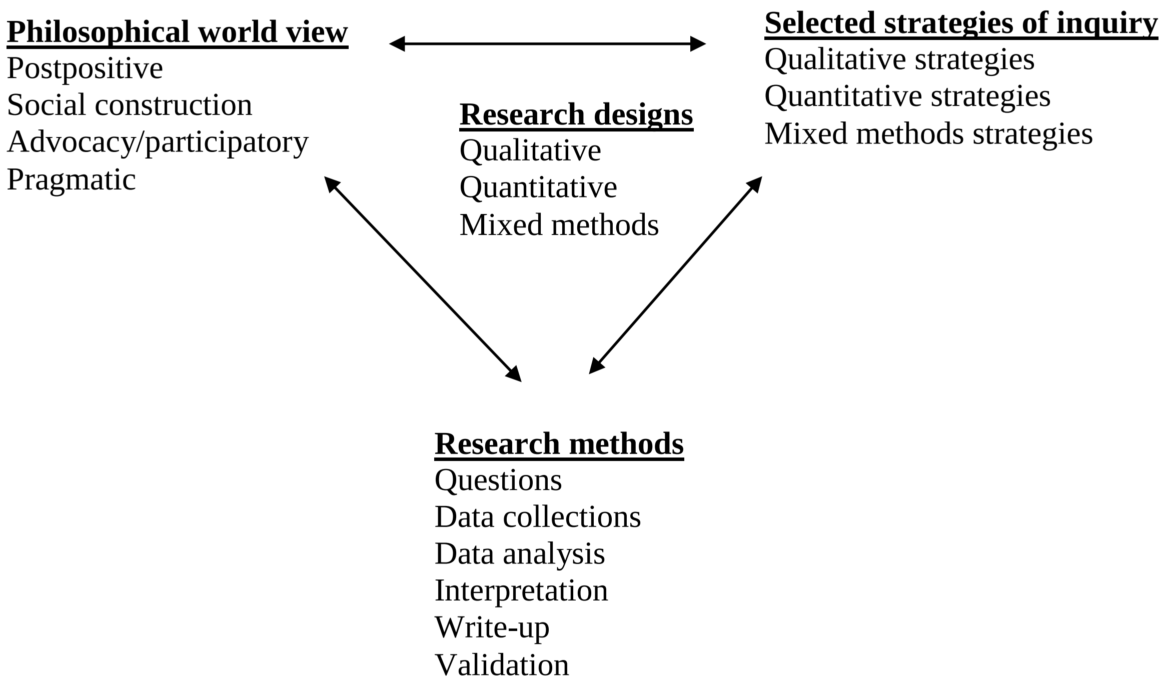


Figure 3.1 Framework for [research] design. Source: Creswell (2009, p.5)

Philosophical world views are represented by four main streams of thought: 1) Postpositive philosophy holds a deterministic view, in which causes probably determine effects or outcomes. This view influences research such that it is considered determination, reductionism, empirical observation and measurement, or

theory verification, 2) Social construction holds assumption that individuals seek understanding of the world in which they live and work. This view emphasizes the research to focus to on participants' understanding, multiple meanings, social and historical constructions, and theory generation, 3) Advocacy/participatory, holds a view that research inquiry needs to be intertwined with politics and a political agenda. This view emphasizes that research should contain an action agenda for reform that may change the participants' lives, the institutions in which individual work or live, and the researcher's life, which is meant to be political, empowerment issue-oriented, collaborative, or change-oriented, while 4) Pragmatic, a worldview arises out of actions, situations, and consequences and is not committed to any one system of philosophy and reality. This perspective leads to be more realistic research by considering consequences of actions, problem-centred, pluralistic, and real-world practices (Creswell, 2009, pp.6-11).

This research, seeking to contribute toward reducing the digital divide through the development and implementation of technology-based tools for use in mathematics education in developing countries, draws heavily on ideas of empowerment and real-world practice as such a pragmatic world view. Encompassing empowerment seems to be more appropriate than the remaining philosophical worldviews.

Selected methods of inquiry, qualitative, quantitative, or mixed methods strategies, are closely related to how the research processes such as questions set, data collections and data analysis, are chosen. The type of the data collected will be dependent on combination of these strategies and associated research methods. Quantitative research is an approach that seeks to determine the relationship between variables and, in particularly cause and effect relationships, while qualitative research, by contrast, is an approach that seeks to make sense of social phenomena as they occur in natural settings (Kervin, Vialle, Herrington, and Okely, 2006, pp. 36-37). Quantitative research will be more numbers driven, positivistic, and traditional, while qualitative research is devoted to developing an understanding of human systems be they small or large (Gog, Paas, et al, 2008, p. 768). Quantitative analysis deals with data in the form of numbers and uses mathematical operations to

investigate their properties, while qualitative analysis deals with data in the form of words, pictures, and even sounds, and to come to some conclusion about what they reveal (Walliman, 2010, p. 113 and 131). Quantitative research provide precision and control in the research process, however this type of research is too mechanistic to adequately capture the complexity of human behaviour (Kervin, Vialle, Herrington, and Okely, 2006, p. 36). On the other hand, qualitative research produces the richer and more varied insights into educational settings than quantitative research (Kervin, Vialle, Herrington, and Okely, 2006, p. 37). The mix between quantitative and qualitative methods in this research will be of benefit not only to provide precision and control but also a richer and more varied insights. According to Creswell (2009, p. 4) mixed methods research is an approach to inquiry that combines or associates both qualitative and quantitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study.

Historically there has been much debate over appropriate methods, research design and how one determines if they are appropriate. The determination of appropriateness of methods varies according to whether or not data are quantitative or qualitative. For example in terms of measuring instruments, quantitative researchers focus on validity and reliability of instruments whereas qualitative researchers tend to rely on alternatives such as credibility or authenticity.

Validity is a term that indicates the authenticity of the data; asking whether the instrument measures what it intends to measure, while reliability refers to the consistency of measures to produces similar results over repeated measurements (Kervin, Vialle, Herrington, and Okely, 2006, pp. 36-37). As explained by Mertens (2010, p. 351), the purpose of data collection is to learn something about people or things and for data to be useful it needs to be gathered using methods that are appropriate, including the validity and reliability of instruments used to collect the data. From the quantitative methods perspective, there are 13 validity criteria:

Table 3.1 Criteria of instrument validity

No	Validity criterion	Description
1	Face validity	The instrument seem to measure what it is supposed to measure
2	Construct validity	The instrument's result is consistent with what else is known or theoretised about the phenomenon of interest
3	Content validity	The instrument deals with all relevant aspects of what it is supposed to measure
4	Criterion validity	The instrument's results correlate with results from another instrument or accurately predicts some later state of affairs
5	External validity	The instrument produces equivalent measures for a much wider population than it has in fact been used with or over longer time period
6	Reproducibility	The instruments produce the same results with the same subjects on another occasion
7	Inter-rater reliability	The instrument's results will be same where ever an administrator or other person uses it
8	Internal consistency	Several items of the instrument, purported to measure aspects of the same phenomenon, results in sufficient correlation between this items
9	Comprehensibility	The subjects understand the language and the concepts entailed in the instruments
10	Acceptability	The instrument is non threatening and inoffensive and the time required to complete the instrument is reasonable
11	Appropriateness to context and target	The instrument is appropriate for the subject group
12	Data and data level	The instrument produces data in the form and at a level appropriate to the best means of statistically analysing the results
13	Usefulness	The instrument is designed to be of practical use

Source: (Gomm, 2008, pp. 34-39)

In relation to reliability, there are three approaches: 1) Reliability is determined by either comparing consistency of responses through repeated measures, or through an equivalent test, 2) Reliability is measured in terms of internal consistency where only one administration of an instrument is used to measure a particular attribute, and 3) Reliability with consistency between observers collecting quantitative data through observation.

Validity and reliability are criteria used in natural sciences, and traditionally accepted by many researchers. However some qualitative researchers have suggested that they [validity and reliability] are not appropriate for the study of the social world, which is made of meanings, rather than of materials and forces (Gomm, 2008, p. 13). Alternative criteria have been proposed as presented in Table 3.2.

Table 3.2 Alternative for validity and reliability for qualitative research

Traditional criteria	**Alternatives for qualitative research**
Internal validity	Credibility or authenticity
Reliability	Dependability or auditability
External validity	Transferability or fittingness
Objectivity	Confirmability
Usefulness	Applicability

Source: adapted from (Gomm, 2008, p. 13)

Triangulation is an important component of qualitative and mixed method research as it an important part of establishing the alternative. Triangulation involves checking information that has been collected from different sources or methods for consistency of evidence across sources of data (Mertens, 2010, p. 258), comparing the data with data produced through alternative means (Gomm, 2008, p. 204), and comparing multiple data sources to build a coherent analysis (Kervin, Vialle, Herrington, and Okely, 2006, p. 87). Researchers may assess validity through triangulation of results (Hesse-Birer, 2010, p. 106). Some researchers classify triangulation as 1) Data triangulation, using different sources of information in order to increase the validity of study, 2) Investigator triangulation, using several different investigators in the analysis process, 3) Theory triangulation, involves the use of multiple perspectives to interpret a single set of data, 4) Methodological triangulation, involves the use of multiple qualitative and/or qualitative methods to study the program, and 5) Environmental triangulation, involves the use of different locations, setting, and other key factors related to the environment in which the study

took place, such as the time, day or season (Guion, Diehl, and McDonald, 2011, p. 1-2).

Data triangulation may involve the use of multiple types of data, from both quantitative and qualitative methods as represented in Table 3.3

Table 3.3 Comparison of qualitative, quantitative, and mixed methods

Quantitative methods	Mixed Methods	Qualitative Methods
• Pre-determined • Instrument-based questions • Performance data, attitude data, observational data, and census data • Statistical analysis • Statistical interpretation	• Both pre-determined and emerging methods • Both open- and closed-ended questions • Multiple forms of data drawing on all possibilities • Statistical and text analysis • Across databases interpretation	• Emerging methods • Open-ended questions • Interviews data, observation data, document data, and audio-visual data • Text and image analysis • Themes, patterns interpretation

Source: Creswell, 2009, p.15

In accord with the concept of triangulation this research involved the compilation of survey reports, data gathering from teachers and students, using both qualitative and quantitative methods with observations, interviews and survey gathering in an accessible area, in Indonesia.

This project involves a sequence of activities from establishing the needs of teachers in developing countries to extending the use of the software tools developed. The data collection activities, both quantitative and qualitative, that form this research, the type of data collected and the research criteria addressed is presented in Table 3.4.

Table 3.4 Research activities and type of data collected

Activity	Data collection		Note on triangulation using alternative criteria
	Quantitative	Qualitative	
Compilation of survey reports regarding ICT in developing countries to document conditions	• Quantitative data of ICT condition in developing countries	• Qualitative data of ICT condition in developing countries	Investigators and environmental triangulation use different sources of surveys results from well-known organizations for regions in developing countries.
Observation of ICT conditions in Bojonegara Sub District, Banten Province, Indonesia	• Questionnaire	• Interview of 12 teachers • Documentation (photos and videos)	Data and methodological triangulation based on three different but similar purpose of instruments 1) questionnaire, 2) interviews, and 3) and documentation to gather information of ICT condition for same school or area. Credibility, auditability, and confirmability criteria of the instruments are maintained during construction and uses.
Software development		• Requirement analysis • Documentation of design and coding • Testing results	Credibility, auditability, and applicability criteria are maintained during designs and development process.
Implementation	• Questionnaire	• Interview of 13 teachers • Documentation (photos and videos)	Data and methodological triangulation based on three different but similar purpose of instruments 1) questionnaire, 2) interviews, and 3) and documentation to assess technology-based tools implementation for teacher or school. Credibility, auditability, and confirmability criteria of the instruments are maintained during construction and uses.
Extend usability	• Students' pre- and post-tests	• Interview • Photos • Videos • Documents analysis	Different instruments 1) quizzes to measure performance, 2) questionnaire to asses opinion, 3) interviews guide to assess opinion, and 4) documentation to confirm applicability, ensuring credibility, auditability, transferability, and applicability are maintained.

One crucial component of this research involves a mixture of data gathering techniques as it relates to the design and development of software tools. Design and development research can be defined as the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non instructional tools and new or enhanced models that govern their development (Ross, Morrison, Hannafin, Young, et al, 2008, p. 751). Furthermore, the author also stated that this research is closely related to mixed methods as following:

> *Design and development research tends to be complex methodologically. This is typically because of the complexities of real-life situations and of the design and development process themselves. This research tends to employ either mixed-method or multiple method approach* (Ross, Morrison, Hannafin, Young, et al, 2008, p. 751)

3.2 Design and development research

Design and development research seeks to create knowledge systematically derived from practice (Ross, Morrison, Hannafin, Young, et al, 2008, p. 748).

> *Design and development research cover a wide spectrum of activities and interest. In its simplest from, it can be either (1) the study of the process and impact of specific design and development efforts, or (2) the study of design and development process as a whole, or of particular process components.* (Ross, Morrison, Hannafin, Young, et al, 2008, p. 748)

The main purpose of the research is to develop ICT-based tools to facilitate implementation of ICT in mathematics education in developing countries and as such the process of design and development is crucial to thesis. The process requires participation of practitioners and mathematics teachers in their normal working environment.

> *Design and development studies often involve collaboration between researcher and practitioners using a wide range of qualitative and quantitative techniques. Together they work to add to the instructional design*

> *knowledge based by studying the nature of the designer and the design processes, often using projects from natural work environment.* (Ross, Morrison, Hannafin, Young, et al, 2008, p. 749)

According to (Ross, Morrison, Hannafin, Young, et al, 2008, p. 749) there are two types of design and development research, depending on their general outcomes: 1) Tool and tools research, and 2) Model research, which pertain to studies of the development, validation and use of design and development models. In term of generalisation of design and development research results, this method encompasses studies with conclusions that are both generalisable and contextually specific. This reflects the fact that tool development typically involves studies that describe and analyze the design and development process, used in particular projects and are to a great extent context bound.

In this research project, the design and development of ICT-based tools for use by mathematics teachers is conducted in an accessible area of a developing country. It is recognised that the tools developed are to a great extent context bound. The data collections are sequential in nature as is common in mixed methods approaches. In this study the design and development work can be seen to progress through four phases, before initiating a new cycle of review and refinement.

3.2.1 Phase I: Localised study of ICT conditions

The broad context for this research project is on improving education in developing countries. The creation, use, and evaluation of technology-based tools for use by mathematics teachers in developing countries requires identification of the physical state of current ICT in these countries. To do this in the first instance a literature review was undertaken of ICT conditions in developing countries and this was complemented by localised investigations in one accessible area in Indonesia as represented in Figure 3.2.

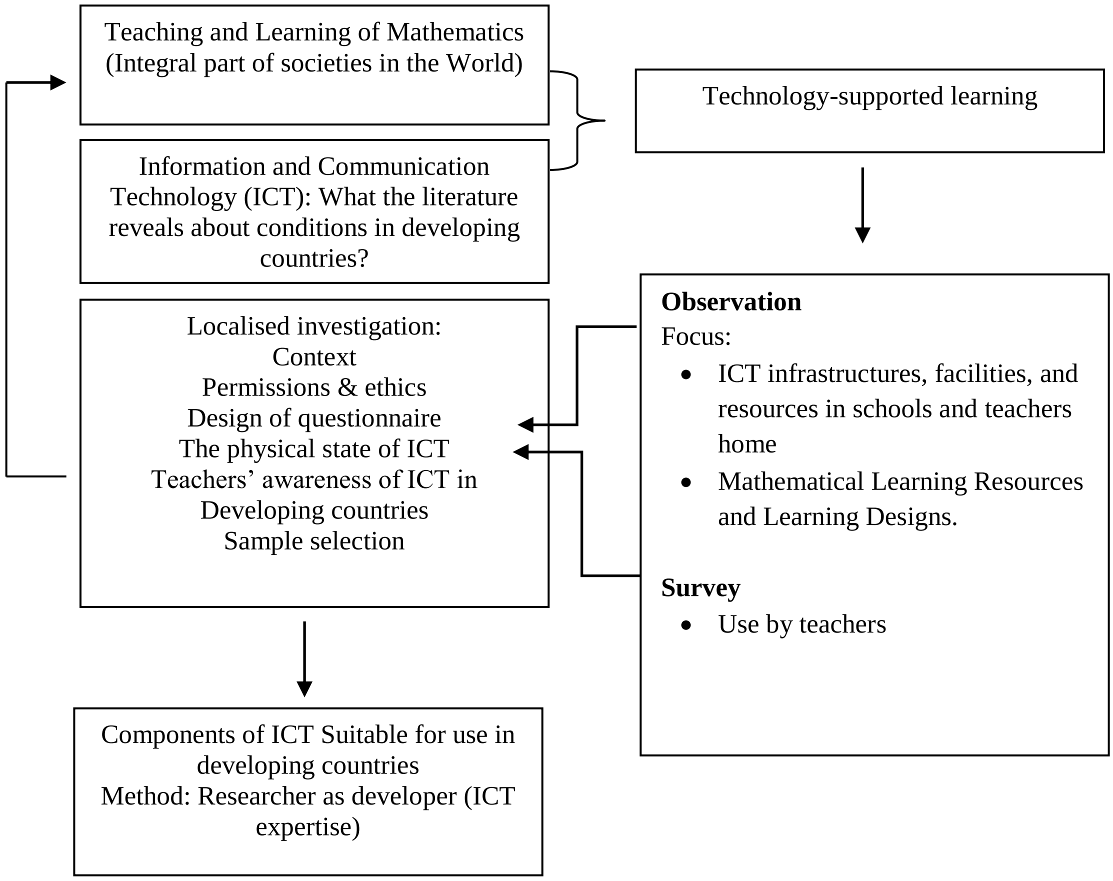


Figure 3.2 General concept of technology-based teaching and learning

Observations of the physical aspects of ICT together with teachers' survey regarding their awareness of ICT in a location of interest, in the developing country of Indonesia was undertaken to collect data regarding ICT conditions. The software tools developed, needed to function with currently used technology.

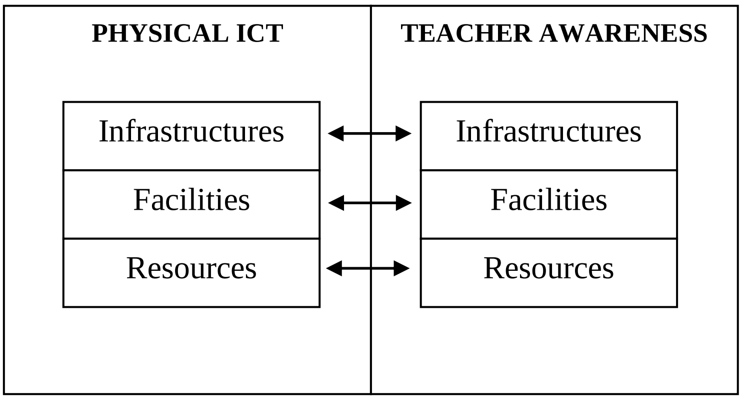


Figure 3.3 Concept of localised study

In the next sections, a description will be given concerning the various ICT components available for use in developing countries and selected in this thesis.

3.2.1.1 Information and Communication Technology: The Literature

ICT refers to all technology that supports the manipulation and communication of information (Cennamo, Ross, and Ertmer, 2010, p. 3). The questions and focus of observation were determined by analysis of reports regarding the key components of ICT infrastructure. Answers to these questions or confirmation as to the various ICT components available for use in developing countries were to shape how the learning tools were created. Types of ICT related to this research are the operating system and the access to the internet which are essentials usages of computers, along with the available technologies that are related to the development of software applications for the selected operating system.

1) Operating system

The first component of technology to be considered was the operating system within which tools developed were to be used. An operating system is a program that manages the computer hardware. It also provides a basis for application programs and acts as an intermediary between the computer user and the

computer hardware (Silberschatz, Galvin, and Gagne, 2005, p. 3). A list of operating system is displayed in Table 3.5.

Table 3.5 Popular Operating Systems

No	Name of Operating System	Company or developer	Initial release	License
1	UNIX	Bell Labs	1969	Proprietary
2	CTSS (The Compatible Time-Sharing System) and MULTICS	MIT's computation and GE, Bell Labs for MULTICS	1961	MIT License
3	BSD (Berkeley Software Distribution)	CSRG, UC Berkeley	1977	BSD Licenses
4	DOS (Disk Operating System)	IBM and Microsoft	1981	Proprietary commercial
5	Mac OS	Apple	1984	Proprietary EULA
6	Windows	Microsoft	1985	Proprietary commercial
7	AmigaOS	Commodore International, Haage & Partner, Hyperion Entertainment	1985	Proprietary
8	OS/2 and OS/360	IBM and Microsoft	1987	Proprietary
9	Linux	Various people and organizations	1991	Various types of license
10	BeOS	Be Inc	1991	Proprietary
11	Solaris	Oracle Corporation	1992	Various types of license
12	FreeDOS	Jim Hall and the FReeDOS team	1998	GNU GPL with some freeware licensed utility
13	ReactOS	ReactOS Foundation	1998	GNU GPL, LGPL, BSD Licenses
14	MorphOS	The MorphOS Development Team	2000	Proprietary with GNU GPL Ambient User Interface
15	Android	Google, Open Handsets Alliance, Android Open Source Project	2003	Apache License, Linux kernel patches under GNU GPL v2
16	iOS	Apple	2007	Proprietary EULA except for open source components

Source: (Silberschatz, Galvin, and Gagne, 2005, and Wikipedia, 2013)

Microsoft Windows is the most popular operating system used for personal computer with over 90 per cent market share. According to Stat Counter Global Stat (2013) as displayed in Table 3.6, the Windows Operating System is used by around 90.85 per cent of computers in developing countries to gain access to the internet. The breakdown according to version is Windows 7 (56.9 per cent),

Windows XP (28.3 per cent), Windows 8 (2.9 per cent), and Windows Vista (2.8 per cent).

Table 3.6 Percentage of usage share of operating systems in developing countries

Area	Windows				Mac		Other		
	Win 8	Win 7	Win XP	Win Vista	MacOSX	iOS	Android	Linux	Other
Africa and the Middle East	2.6	58.5	26.1	3.0	4.0	3.1	0.9	0.6	1.3
Latin America and the Caribbean	3.2	57.6	22.5	4.6	5.8	2.7	0.7	1.2	1.7
India and South Asia	3.4	58.7	31.2	1.7	1.8	1.0	0.0	1.3	2.0
Asia Pacific (without India and South Asia)	2.3	52.7	33.4	1.9	3.0	3.6	1.6	0.2	1.1
Total	2.9	56.9	28.3	2.8	3.7	2.6	0.8	0.8	1.1

Source: Adapted from Stat Counter Global Stat (2013), http://gs.statcounter.com/

For the country of prime interest and the site of data collection in this study, Indonesia, Windows is the dominant operating system with minor use of other systems such as Android (refer Table 3.7).

Table 3.7 Percentage of usage share of operating systems in Indonesia

Area	Windows				Mac		Other		
	Win 8	Win 7	Win XP	Win Vista	MacOSX	iOS	Android	Linux	Other
Indonesia	3.3	46.5	41.1	1.1	1.8	2.1	3.2	0.6	0.2

Source: Adapted from Stat Counter Global Stat (2013), http://gs.statcounter.com/

Based on these results, Windows and, in particular Windows 7 and Windows XP, were targeted for use when developing applications for use by mathematics teachers in developing countries, in particular Indonesia.

2) Internet

The second key component of infrastructure is the internet, a global system of interconnected computer networks. It is a network of networks that consists of millions of private, public, and organizations' computer networks. The internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the World Wide Web (WWW) and the infrastructure to support email. The internet has been adapted for use in education, from elementary school to university and beyond. Educational resources accessible via the internet can be used by many people around the world as long as the internet connection is of suitable bandwidth and available for those people. Sauers (2001) in his book *Using the Internet as Reference Tool* briefly explains the role of the internet as reference tool. In addition, Sauers (2001, p. 3) emphasizes that the internet can help people, in regard to internet accessible resources with the advantages that: 1) Internet resources are accessible from any connected computer, 2) Internet resources can be more current than say print versions, and 3) Many people can access internet resources at the same time. Of key concern in this thesis is the nature of internet access, such as speed and reliability, and its use for teachers and students.

3) Visual Basic

A programming language is required to develop software applications for the Windows operating system chosen given its wide used in developing countries. One popular programming language and familiar to the author is Visual Basic (VB). Visual Basic is a programming language and Integrated Development Environment (IDE) developed by Microsoft that can be used to develop software applications and games for windows operating system environments. A software application developed using visual basic, in general, will consist of two main parts: 1) Data, which is to be processed, and 2) Instructions, or the way data is processed or analysed (Loffelmann and Purohit, 2011, pp. 10-11). Based on this concept, the workflow of the software application developed in this thesis will

consist of 1) data related to resources and learning designs and 2) instructions, about how the data of resources and learning designs will be processed using the software application.

Key features considered in the choice of the program and necessary for the development of the software tools in this thesis include its ability to process different data types, use different operators, write for multiplatforms, use an integrated development environment, use arrays and serialisation

a) Data types

There are six data types supported by visual basic: 1) single and double, 2) decimal, 3) date, 4) Boolean, 5) character, and 6) string.

b) Utilise Boolean and other common operations

Based on these data types, the data of resources and learning designs need to be adapted to one of these data type to be processed or executed using conditional decisions (such as *if ... then ... else... End if*), the logical operators (such as *Or* and *And*), comparison operators (such as *expression1* < *expression2*), and loops (such as *For ... Next*) (Loffelmann and Purohit, 2011, pp. 10-51), and through the combination of these data types and various instructions, a software application can be developed to be executed or run under Windows operating system.

c) Ability to write for multiplatform computers.

The variability of the computer devices (type of computers, processors, graphic cards, version of Windows) and the complexity of programming language have to be addressed in order to simplify the programming language. Microsoft, as the creator of Visual Basic, has integrated the .NET Framework to Visual Basic. The .Net framework is a collection of various technologies that share a common infrastructure and that offer software developers the opportunity to develop safe, stable, easily

maintainable, multiplatform software for both browser oriented and smart client applications (Loffelmann and Purohit, 2011, p. 65).

d) Integrated Development Environment

The development of software applications using Visual Basic can benefit from an Integrated Development Environment (IDE). The developer can design application forms using Windows Form Designer before writing the programming code used to run the application. There are many controls available for drag and drop to the windows form, like Button, Text Box, Label, Tab Page, Data Grid, etc. The platform for the programming language is Windows.

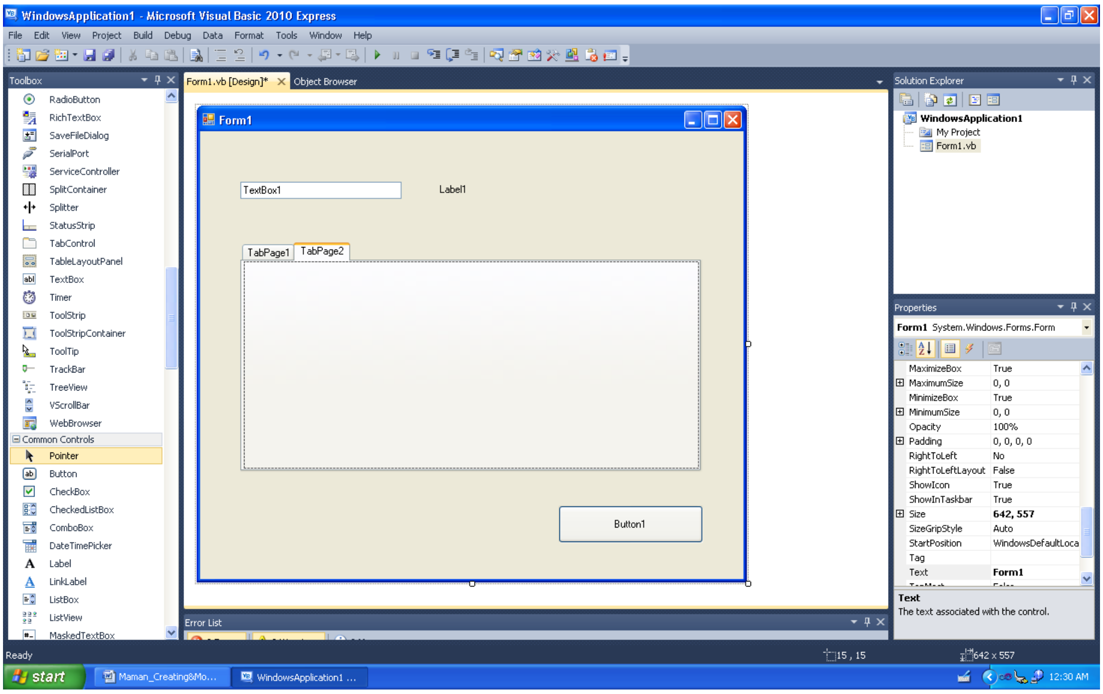


Figure 3.4 Windows Form Designers and Its Controls

e) Arrays and serialisation

The support of .Net frameworks in Visual Basic enables developers to program data structures with arrays and serialization. An array can be used

to hold a number of elements of the same data type, making all the elements available by using a single name or identity (Loffelmann and Purohit, 2011, p. 624). While serialization facilitates the retrieval of the data from an object, in which the procedure to retrieve the data must query the object sequentially, process the data, and then do something with it (Loffelmann and Purohit, 2011, p. 624).

f) Database retrieval

Visual Basic also can facilitate the retrieval of the data stored in a database (like MS Access and XML files) as some control functions in Visual Basic such as BindingSource, DataSet, and DataGridView are available to enable developer to connect database files to visual basic applications.

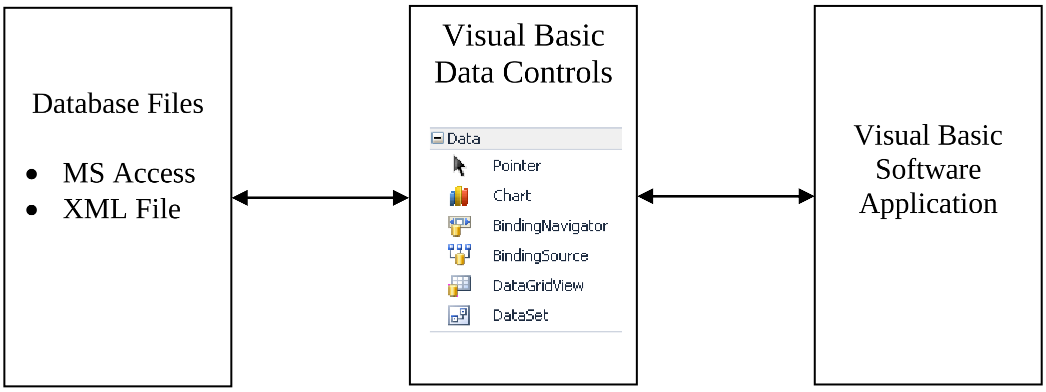


Figure 3.5 Role of visual basic data controls in connecting database to application

4) Database and electronically stored information

A database is defined as any organized collection of data that has a relationship with each other (MacDonald, 2013, p. 91). MacDonald (2013, p. 91) argues that databases are extremely important because with nearly every type of application a user interacts with on a computer or the internet will use some type of database to organize and manage the user experience and the data they create. As illustrated in Figure 3.5, a database file is one of components that the software application developed with visual basic will work with. The database to be used

in this thesis is an electronic file that is modifiable and shareable. Using databases, information can be stored for later use. This concept is known as the Electronically Stored Information (ESI). For example the system proposed by Yao, Trappey, and Ho (2003) about electronic document management system based on XML. In regard to mathematical learning resources and learning designs, databases are required to store and manage information related to in this thesis a resource map or learning design map.

5) XML (eXtensible Markup Language) technology

XML stands for eXtensible Markup Language. According to Tittel, Pitts, and Boumphrey (2002, p. 113) XML is a programming language based on the Standard Generalized Markup Language (SGML). XML can be used to structure and describe data, and has wonderful mechanism for transferring data between disparate systems. In addition, Miller and Clarke (2004, p. 1) defined the XML as a system for electronically tagging or marking up documents in order to label, organize, and categorize their content, while Goldfarb (2004, p. 6) defined the XML as a framework for any project that involves moving information from place to place, even between different software platforms.

Based on these specifications and explanation, it is known that the XML is a technology that enables labelling, organizing, and categorizing data or document in order for moving data or documents from one platform to another platform. In terms of this thesis, resources and learning designs are the data of interest, and these through XML can be used and moved from one platform to another platform. The integration of the XML in the software application also allows data to be transferred using Microsoft Office. Using XML in the implementation of the software tools to be developed provides the following benefits:

- information capture and reuse
- end-user data connection
- data-driven application enhancement

> This functionality of XML can enable development tools for working with data, in this instance as it emerged a tool to create and capture data from teachers or lecturers in the form of resources and learning designs that can then be reused for other purposes, such as, curriculum review.

3.2.1.2 Context

The basis of the design and development is to fulfil teachers' needs given the ICT they have access to. Hence, the purpose of the data collection in this phase is to learn about and confirm literature findings regarding the physical state and teachers' awareness of and access to ICT infrastructure, facilities and resources. One area in a developing country Bojonegara Sub District, Indonesia was chosen as an area in a developing country in which to collect data.

In Bojonegara Sub District, Indonesia educational matters are managed by the Education Office Sub District branch. The Education Office at the District and Province levels has similar functions to the education office in the Sub District, but with a wider rights and responsibilities than the Education Office Sub District branch, such as recruiting public servants and teachers to be distributed throughout the province, subject to approval from the Indonesian Government. At the national level, the Ministry of Education and Culture also has several initiatives related to ICT (Ministry of Education and Culture). These initiatives usually relate to national curriculum and educational contents. The Ministry of Education and Culture also provides financial grants for schools in Indonesia through calls for proposals funded through competitive projects.

To support educational ICT, the Education Office branch has several programs that supply school ICT facilities and equipment along with training teachers or staff that will use these facilities. The equipment supplied is done in cooperation with several companies. Further, the Education Office at Sub District branch also regulates the administration and management of teachers and staff of the schools under its responsibility, including transferring teachers' salary and wages.

3.2.1.3 Observation

In general two components were the focus of the localised study (refer Figure 3.3), the physical state of ICT and teachers' awareness. The physical state referred to the facts about ICT infrastructure, facilities, and resources that actually exist in the Bojonegara Sub District, Banten Province, Indonesia that were available to support technology-based teaching and learning experiences. The teachers' awareness referred to what the teachers were aware of and what they understood about ICT infrastructure, facilities, and resources available to support technology-based teaching and learning experiences in the Bojonegara Sub District. It was expected that the information regarding the physical ICT infrastructure, facilities, and resources could be compared to the information regarding to the teachers' perceptions as the availability of ICT infrastructure, facilities, and resources in order to gain perspective about what was needed in terms of software development during the second phase.

Table 3.8 Localised study focus

No	Focus			
	ICT Condition at School	ICT Condition at Home	Learning Resources	Learning Designs
1	Condition of computer laboratory and its use on teaching and learning.	Condition of computer and its use for teaching and learning.	Current condition of available learning resources.	Current condition of learning designs and its share in the school.
2	Condition of notebooks computer and projectors and its use on teaching and learning.	Condition of printer and scanner and its use for teaching and learning.	Types of learning resources at schools.	Teachers' opinion on implementation of technology-based teaching and learning designs and its potential problems.
3	Condition of internet access and its use on teaching and learning	Condition of internet access and its use for teaching and learning	Teachers' opinion of implementation of technology-based teaching and learning resources and its potential problems	Teachers' initiative on developing learning designs
4	Condition of official website or blog and its use on teaching and learning	Condition of personal website or blog and its use for teaching and learning	Teachers' experiences on creating, modifying, and sharing learning resources	Learning resources of technology-based teaching and learning designs
5	IT Staff/support	IT Assistance/help		
6	Internet access using hand phone in schools	Internet access using hand phone at home		
7	General information of ICT at schools	Frequently used software		
8		General information of ICT at home		

3.2.1.4 Permission, ethics, and instruments for data collection

According to DeVaus (2002, p. 59) there are five ethical responsibilities towards survey participants: 1) voluntary participation, 2) informed consent, 3) no harm, 4) confidentiality anonymity, and 5) privacy. The first step in the localised investigation involved gaining ethics approval for the study from the Human Research Ethics Committee (HREC) at the University of Wollongong, NSW, Australia. Key features of the ethics approval process included provision of Bojonegara Education Office with an approval letter (Appendix I) and Instruments used in the data collection process, refer Figure 3.6, include a Participant Information Sheet (Appendix II), Informed Consent Form (Appendix III), Questionnaire (Appendix IV), and Guidelines for interview (Appendix V), and these in turn were necessary to the obtain HREC approval letter (Appendix VI). A handy cam was used to take pictures and videos of related infrastructure, facilities, and resources available in the Indonesian region of study. The video camera is also used to record interview session with teachers. Photos documentation of the area and schools environment, and teachers' classrooms, are enclosed in the appendix VII.

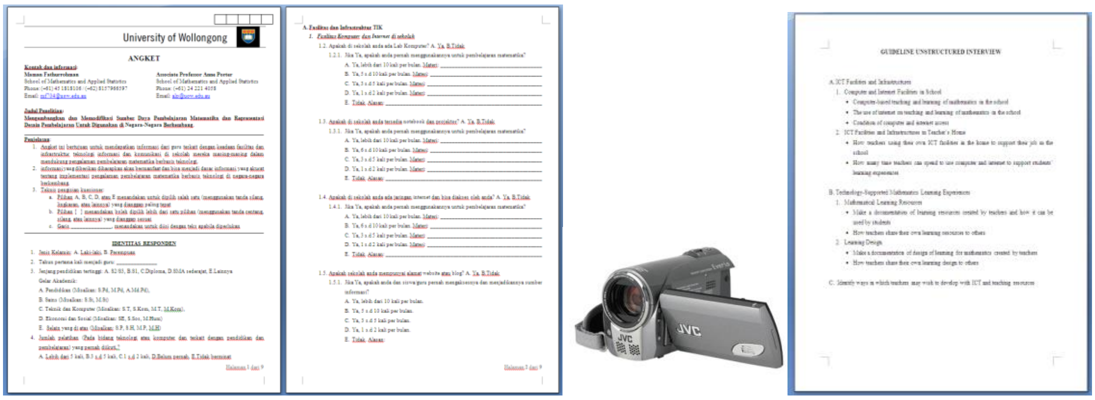


Figure 3.6 Instruments used in data collection

To triangulate findings, the researcher used the observations in addition to questionnaires, photo and video documentation, and interviews of principals and teachers.

3.2.1.5 Questionnaire design

The questionnaire consisted of 27 main questions. For each teacher, gender, working experiences, academic degree and field of study, and training in ICT was documented along with ICT conditions at school and home, and their experiences or access to learning designs and resources. The questionnaire and teacher interviews gathered data about teachers' awareness of ICT conditions and its infrastructure, facilities, and resources available in their area in Indonesia to support technology-based teaching and learning experiences.

The initial questions, refer Table 3.9 provides information as to the teacher respondents' identity in terms of items such gender, length of time in the school. Their working experiences, ICT skills and training rather than the teacher's name.

Table 3.9 Questions to establish respondents' identity

RESPONDENT'S IDENTITY

1. Gender: A. Male, B. Female
2. Working in this school since: _____________
3. Higher Achieved Academic Degree:
   A. Master/Doctorate
   B. Bachelor
   C. Diploma
   D. Secondary School
   E. Others

   Field of Academic Degree:
   A. Education (For example: S.Pd, M.Pd, A.Md.Pd),
   B. Science (For example: S.Si, M.Si)
   C. Engineering or Computer (For example: S.T, S.Kom, M.T, M.Kom),
   D. Economic or Social (For example: SE, S.Sos, M.Hum)
   E. Others
4. Number of training (sessions) related to technology and computer for education:
   A. More than 5 times
   B.3 to 5 times
   C.1 to 2 times
   D. Never participation
   E. Not interested

ICT condition are closely related to technology-based teaching and learning, as teachers use the ICT available at their schools to implement their teaching pedagogy. For that reason, questions regarding ICT facilities and infrastructure at school were asked to ascertain what was available to the teachers to use and how frequently they

used it. Using these questions, researchers explored computer and internet facilities available at schools (refer Table 3.10). The questions in regard to computer and internet at schools explore the availability of computer laboratories and related devices (laptop, projector), schools' official web pages and their current use in teaching and learning. Other questions asked teachers about ICT staff and internet access at their schools. The last question is an open ended question to allow teachers to provide information related to ICT facilities and infrastructure at their schools.

Table 3.10 Questions to identify technology available at school

A. ICT Facilities and Infrastructures

1. Computers and internet facilities at school

1.1 Is there any computer laboratory in your school? A. Yes, B. No
1.1.1 If you answer Yes, have you use it for teaching and learning?
A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic: _______________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

1.2 Is there any notebook or projector in your school? A. Yes, B. No
1.2.1 If you answer Yes, have you use it for teaching and learning?
A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic:________________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

1.3 Is there any internet access in your school? A. Yes, B. No
1.3.1 If you answer Yes, have you use it for teaching and learning?
A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic:________________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

1.4 Is there any official website or blog about your school? A. Yes, B. No
1.4.1 If you answer Yes, have you and your students accessed it and used it as a source of information?
A. Yes, more than 10 times per month.
B. Yes, 6 to 10 times per month.
C. Yes, 3 to 5 times per month.
D. Yes, 1 to 2 times per month
E. No. Because: ____
1.4.2 If you answer Yes, please give more explanation about your school's website or blog (for example: web address, how to use it, who manages it)? _________

1.5 Is there any special ICT staff in your school? A. Yes, B. No
1.5.1 If you answer Yes, how many times he/she present in your school?
A. Everyday
B. 3 to 5 times per week.
C. 1 to 2 times per week.
D. No specific schedule.

1.6 Do you have an access to internet at school using your hand phone?
A. Yes, B. No
1.6.1 If you answer Yes, how many times in one day you access internet using your hand phone?
A. More than 5 times per day
B. 3 to 5 times per day
C. 1 to 2 times per day
D. Never.

1.7 Do you have additional information to explain related to ICT Facilities and Infrastructures in your school? (Maybe related to its usefulness, problems, etc). Please write it below
____

In addition to ICT available at school, teachers can use ICT available at their home for the implementation of technology-based teaching and learning. For that reason, the questions in regard to computer and internet at home (refer Table 3.11) explore the availability of personal computer and related devices (printer and scanner), personal web page and its current usage to support teaching and learning.

Table 3.11 Questions to identify technology available at home

A. ICT Facilities and Infrastructures

2. Computers and internet facilities at home

2.1 Is there any computer in your home? A. Yes, B. No

2.1.1 If you answer Yes, have you use it to prepare teaching and learning?

A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic:________________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

2.2 Is there any printer or scanner in your home? A. Yes, B. No

2.2.1 If you answer Yes, have you use it to prepare teaching and learning?

A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic:________________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

2.3 Do you have an internet access in your home? A. Yes, B. No

2.3.1 If you answer Yes, have you use it to prepare teaching and learning?

A. Yes, more than 10 times per month. Topic:___________________________
B. Yes, 6 to 10 times per month. Topic:________________________________
C. Yes, 3 to 5 times per month. Topic:_________________________________
D. Yes, 1 to 2 times per month. Topic:_________________________________
E. No. Because: ____

2.4 Do you have a personal website or blog? A. Yes, B. No

2.4.1 If you answer Yes, have you used it for course delivery to your students or as a source of course information?

A. Yes, always.
B. Yes, sometimes.
C. Yes, rarely.
D. Yes, once.
E. No. Because: ____

2.4.2 If you answer Yes, please give more explanation about your personal website or blog (for example: web address, how to use it, who manages it)? ___________________

2.5 Do you have a member of family who can help you using ICT facilities in your home? A. Yes, B. No

2.5.1 If you answer Yes, how many times this person present in your home?

A. Everyday
B. 3 to 5 times per week.
C. 1 to 2 times per week.
D. No specific schedule.

2.6 Which software do you frequently use and familiar with?

[ ] Specialized Educational Software, name of software: __________________
[ ] Word Processor (for example: MS Word), you use it to: ________________
[ ] Presentation (for example: Power Point), you use it to: _________________
[ ] Spreadsheet (for example: MS Excel), you use it to: ___________________
[ ] Music and Video related software, name of software: __________________
[ ] Game, name of software: ____
[ ] Others, name of software: ____

2.7 Do you have an access to internet using your hand phone in home? A. Yes, B. No

2.7.1 If you answer Yes, how many times in one day you access internet using your hand phone in home?

A. More than 5 times per day
B. 3 to 5 times per day
C. 1 to 2 times per day
D. Never.

2.8 Do you have additional information to explain related to ICT Facilities and Infrastructures in your home? (Maybe related to its usefulness, problems, etc). Please write it below

____

Other questions asked teachers about support from family member for use ICT facilities at home, list of software type familiar to them, and internet access at their home. The last question is an open ended question to allow teachers to provide information related to ICT facilities and infrastructure at their home.

Some teachers, due to their ICT skills may have had experiences in using technology for teaching and learning. For that reason, questions regarding technology-based teaching and learning experiences were provided to ascertain the current practice of technology-based teaching and learning and teachers' view for the implementation of technology-based learning resources (refer Table 3.12). In detail, the questions in regard to learning resource explore the current practice with use of technology-based learning resources, identification of the type of learning resources used by students, teachers' opinion on implementation of technology-based learning resource and potential problems regarding its implementation. Teachers are also asked about their experiences on creating and sharing learning resources.

Table 3.12 Questions to identify technology available at school

B. Technology-based teaching and learning experiences

1. Learning resource

1.1 Would you explain about how students used learning resources in your class:
____
____

1.2. What are types of learning resources which are used by students in your school:
[ ] Printed materials, for example: ____________________
[ ] Physical Media, for example: ____________________
[ ] Digital files, for example: ____________________
[ ] VCD/DVD, for example: ____________________
[ ] Softwares, for example: ____________________
[ ] Game, for example: ____________________
[ ] Others, for example: ____________________

1.3. What is your opinion about the use of mathematical learning resources through technology-supported mathematics learning experiences in your school:
A. It is possible
B. Possible, but difficult to be implemented
C. It is impossible
Explanation: ____________________

1.4. What are problems which would be occur related to above implementation:
[ ] Supporting facilities: ____________________
[ ] Teachers' skills: ____________________
[ ] Students' skills: ____________________
[ ] Education system: ____________________
[ ] Time: ____________________
[ ] Others, for example: ____________________

1.5. Have you created or modified learning resources?:
A. Yes. Topic: ____________________
Explanation: ____________________
B. No. Why: ____________________

1.6. Have you ever shared mathematical learning resources your created? A. Yes, B. No
If you answer Yes, please provide an example: ____________________

Some teachers also may have experiences with technology-based learning design support. For that reason, questions regarding implementation technology-based learning design support (refer Table 3.13) were provided to ascertain teachers' views regarding this practice. In detail, the questions in regard to learning design explore the current practice of how teacher design teaching and learning experiences and how this design is shared to others. Teachers also asked whether they use other teacher's learning design. Teachers are also asked their opinion of technology-supported learning design and potential problems for implementation of technology-based teaching and learning Lastly, teachers were asked if they had experience in initiated technology-based learning design.

Table 3.13 Questions to identify experiences with learning design

B. Technology-based teaching and learning experiences

2. Learning design

2.1 Please explain how you design learning experiences for your class:
____

2.2 How other teachers and you share the design of learning experiences?
____

2.3 Can you use other teachers's design of learning experiences or do others use your design of learning experiences?
If you can, what makes them shareable? ____________________
If not, why not? ________________________________

2.4 What is your opinion about designing learning experiences and its practice through internet or on line platform:
A. It is possible
B. Possible, but difficult to be implemented
C. It is impossible
Explanation: ______________________________

2.5 What are problems which would be occur related to above implementation:
[ ] Supporting facilities: ___________________________
[ ] Teachers' skills: ______________________________
[ ] Students' skills: ______________________________
[ ] Education system: ___________________________
[ ] Time: _____________________________________
[ ] Others, for example: __________________________

2.6 Have you initiated development of design of mathematical learning experiences through internet or on line platform?
A. Yes. Topic: ________________________________
Description of activities or experience: ________________
B. No. Why: __________________________________

2.7 Do you have resources to share related to designing mathematical learning experiences and its practice through internet or on line platform in your school?
Example: ____________________________________

A complete questionnaire is enclosed in the Appendix IV. For research purposes, the questionnaire was written in Bahasa Indonesia, the native language of respondents in Indonesia and translated to English for thesis writing purposes.

3.2.1.6 Guideline for research interview

The purpose of the research interview was to gather richer and more varied insight from teachers, as to their experience of the use of ICT in teaching than the data gathered using questionnaires. The guidelines provided a partial structure to the interview, identifying points to be covered; however the flow of the discussion was semi-structured with the researcher asking questions in accord with the flow of discussion depending in part on the conditions of the schools or information being supplied by the teacher. Whilst interviewing, the researcher on occasions found and allowed interesting topics not listed in the guideline for interviews and/or outside the topic of discussion, for example discussion regarding ICT grants from companies located in Bojonegara Sub District. Subject to the teachers' approval the interviews were video recorded. Transcripts of interviews, translated to English, are included in Appendix VIII.

Table 3.14 Interview guideline

A. ICT Facilities and Infrastructures at Schools

1. Computer and internet Facilities in School
   - Computer-based teaching and learning of mathematics in the school
   - The use of internet on teaching and learning of mathematics in the school
   - Condition of computer and internet access
2. ICT Facilities and Infrastructures in Teacher's Home
   - How teachers using their own ICT facilities in the home to support their job in the school
   - How many time teachers can spend to use computer and internet to support students' learning experiences

B. Technology-Supported Mathematics Learning Experiences

1. Mathematical Learning Resources
   - Make a documentation of learning resources created by teachers and how it can be used by students
   - How teachers share their own learning resources to others
2. Learning Design
   - A documentation of design of learning for mathematics created by teachers
   - How teachers share their own learning design to others

C. Identify ways in which teachers may wish to develop with ICT and teaching resources

3.2.1.7 Data collection procedures

The data collection procedure involved the selection of a sample and an approach to principals and teachers with a view to collecting data.

The first step in sample selections involved identifying the population of interest and how to access the desired participants. Schools in Banten Province are classified as elementary with ages of students 7 to 12, junior high school with ages 13 to 15, and senior high school, ages 16 to 18. A classification of schools and the number of teachers is provided in Table 3.15

Table 3.15 Registered School Teachers in Bojonegara Sub District

No	Level	Number of Schools	Number of teachers	Percentage
1	Elementary School	22	313	53.50
2	Junior High School	9	194	33.16
3	Senior High School	3	78	13.33
Total		34	585	100.00

Source: Ministry of Education and Culture, Republic of Indonesia. (August 2010)

Having determined the breakdown of the population, to facilitate comparisons and to have a sufficiently large sample size, the researcher sought to take a higher proportion of participants from the smaller cohorts. The researcher also considered time constraints and access to schools in choosing the sample. The researcher sought to sample approximately:

- 1/7 of number of elementary schools teachers (1/7x313= 45 teachers)
- 1/5 of number of junior secondary schools teachers (1/5x194= 39 teachers)
- 1/2 of number of senior high schools teachers (1/2x78= 39 teachers)

Once a school was selected for inclusion, being randomly selected from accessible locations in Bojonegara Sub District (some schools are difficult to access by researcher due to their remote locations), a sample of teachers was determined using a random sample of teachers in the Bojonegara Sub District

Following official procedures, the researcher sort permission from Director of Ministry of National Education Office at Sub District Bojonegara to seek school principals' permission to use resources at their school as the researcher collected data from their teachers. The official permission was granted in the form of permission letter (Appendix VI). Following this the principals of the chosen schools were contacted by researcher.

3.2.2 Phase II: Development of software tools

The development of the software tools involved aligning needs of the project with suitable technology and developer expertise. The researcher has a certificate with about 10 years of experience with visual basic and office software design and development. This experience, together with knowledge of the available tools for use in developing countries, identification of the needs of teachers and from the outcomes of the localised investigation led to identification of the features required in the development tools (Section 4.2.2.1). The software tools were to: 1) Be developed for windows operating system using visual basic, 2) Take advantage of internet access for mathematics teachers, 3) Consist of a database to manage information regarding mathematical learning resources and learning designs, and 4) To take advantage from Access and XML technologies, for easy transfer and modifiability of the data, that is of mathematical learning resources and learning designs.

The identified tool to be produced was an electronic mapping system to manage and foster access to mathematical learning resources available via a knowledge management system, in the internet. Knowledge management is the process of capturing or creating knowledge, storing it, updating it constantly, interpreting it, and using it whenever necessary (Turban et al, 2008, p. 393). In this case, the knowledge of mathematical learning resources and learning designs is captured and stored in electronic maps, then updated and used as necessary by mathematics teachers in developing countries. As stated by (Turban et al, 2008, p. 393), one purpose of the

knowledge management system is for knowledge sharing; in this case the electronic map is shared between teachers to allow the distribution of the knowledge. The purpose of the tools is to foster the access by mathematics teachers in developing countries to mathematical learning resources on the internet and to document and share their learning designs. The development of software tools in this study, according to Jalote (2005, p. 16-20) are conducted in four phases in the development process: 1) Requirement analysis, 2) Software design, 3) Coding, and 4) Testing.

3.2.2.1 Requirement analysis

Requirement analysis involves identifying what is needed from the system or in this case software tools. Two major activities in this phase involve understanding the problem and requirement specifications. It was determined, based on the localised investigations that mapping systems be developed to manage the data of mathematical learning resources and learning designs. This meant that the application would deal with database structures and control access to the data stored in the database. Hence, the system developed needed a file, in this instance called, an electronic map that could act as a database for this information. Because this file has specific purpose, a database viewer or reader, a windows-based application that is specially developed to work with this electronic map is required.

3.2.2.2 Software design

Software design involves planning a solution to the problem specified by the requirement analysis. The emphasis in design is how to satisfy the needs as stated in the previous phase. The software was designed as two separate windows applications, one for mapping resources and the other mapping learning designs. However both mapping applications consist of an electronic map and its associate reader. To accommodate teachers need to easily access mathematical learning resources the software is provided with a connect button to easily visit or get a

mapped resources, while the learning design mapping software written in Visual basic has the ability to document and storing data in XML format.

3.2.2.3 Coding

Coding is conducted to translate the design of the system into programming language code. It requires the developer's expertise to write the code and the available tools to support it. Coding conducted using visual basic is implemented to develop two applications for windows as explained in section of software designs. Visual Basic is the programming language familiar to researcher. It is widely known that the coding outcome depends heavily on the ability of the developer to write it. In this case, the coding is conducted based on researcher ability, so the purpose is to develop the concept and to show how the system can be expected to work, not high-end, sophisticated commercial software coded by a professional company.

3.2.2.4 Testing

This phase is conducted as a measure of quality control during software development. The basic function of this phase is to detect defects in the software. System requirements are tested to determine if all the requirements are met. Testing is conducted to check whether as a result of coding, the software tools, can work as expected. The testing is conducted in different computers, in particular with different version of the windows operating system (Windows 7, Windows XP, name them) and different type of computers (laptop, desktop, netbook). The purpose of this activity is to simulate conditions when the software is used in teachers' computer devices, and to find if there are any problems that can be fixed before the software is implemented by target users (mathematics teachers in developing countries).

3.2.3 Phase III: Implementation

In the implementation phase the software tools are trialled in the real setting, in this instance in an area of a developing country, Indonesia. The study was concerned with capturing the responses of 12 mathematics teachers to the tools created to map resources and learning designs. The focus in this study was on the usability of the system in terms of mapping and sharing resources and learning designs.

3.2.3.1 Ethics

In order to collect data permission was obtained from the Human Research Ethic Committee (HREC), University of Wollongong. An official request for permission to collect data was also made of the Head of Education Office in Bojonegara Sub District. Permission was also sought from the Head of each school visited.

3.2.3.2 Data collection instruments

Gathering mathematics teachers' experiences on the electronic mapping system is main focus of the implementation evaluation. Methodological triangulation of the data is conducted through the use of different instruments, questionnaires, and interviews.

1) Questionnaire

The questionnaire for the evaluation of the software implementation consisted of 42 main questions. As for the localized investigation the questionnaire gathered teachers' data regarding, gender, working experiences, academic degree and field of study, and training in ICT. The questions related to teachers satisfaction with and evaluation of the software tools implemented.

The first set of questions, refer Table 3.16 involved an evaluation of the key components of the electronic mapping system for learning resources.

Table 3.16 Questionnaire for evaluation of key components of electronic map

Electronic map

Electronic Map of Learning Resources

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	File Structure					
3	Features					
	Database Structure					
	Entry Data					
	Modifiable and Shareable					
4	Function					
5	Innovation					
6	Capability					

Comment:
____

Electronic Map of Learning Designs

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	File Structure					
3	Features					
	Designing Curriculum-Aligned and Non Curriculum-Aligned Learning Design					
	Converting to HTML to be Accessed via Internet					
	Modifiable and Shareable					
4	Function					
5	Innovation					
6	Capability					

Comment:
____

The second set of questions, refer to Table 3.17 related to the evaluation of the associate reader of electronic maps.

Table 3.17 Questionnaire for evaluation of key components of associate reader

Associate reader

Electronic Mapping System of Resources in the Internet

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	Design					
3	Features					
	Reading Electronic Maps					
	Catalogue and Searching Facilities					
	One Button Click (The use of one button by click it to visit Web Site)					
4	Function					
5	Innovation					
6	Capability					

Comment:
____

Electronic Mapping System of Learning Design

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	Design					
3	Features					
	Reading Electronic Maps					
	Using XML Technology					
	Recording Learning Design					
4	Function					
5	Innovation					
6	Capability					

Comment:
____

The third set of questions, refer to Table 3.18 related to the evaluation of the implementation of electronic mapping system in school and its relation to curriculum.

Table 3.18 Questionnaire for evaluation of implementation and curriculum

Implementation in school or classroom

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Friendly and Easy to Use					
2	Appropriate to Current ICT Condition					
3	Beneficial					
	For Teachers					
	For Students					
	For Schools					
	For Education Office					
4	Institutionalization					
	Implementable					
	Has A Good Impact					
	Maintenance of Product by Teachers or Schools					

Comment:
____

Relation to Curriculum

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Prototype as a Tool Related to Curriculum Development					
2	Prototype as a Tool to Documents Resources and Learning Design					
3	For Electronic Map Aligned to Curriculum					
	Synchronization of Curriculum to Electronic Maps					
	Teacher' Ability on Creating Electronic Maps					
	Teacher' Wish to Share Their Own Electronic Maps					
4	For Electronic Map Not Aligned to Curriculum					
	Allowing Teachers to Create Their Own Curriculum for A Special Teaching					
	Teacher' Ability on Creating Electronic Maps					
	Teacher' Wish to Share Their Own Electronic Maps					

Comment:
____

The fourth set of questions, refer to Table 3.19 related to the evaluation of appropriateness of the electronic mapping system for use in developing countries and its future development.

Table 3.19 Evaluation of appropriateness for developing countries

Appropriateness for Use in Developing Countries

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Appropriate for Teachers					
2	Appropriate to Current ICT Condition					
3	Could be Implemented in Developing Countries					
4	Could be Institutionalized in Schools					
5	Recommended to be Used by Other Teachers.					

Comment:
____

Future Development

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Tools could be used in developing countries					
2	Tools could be used in developed countries.					
3	Tools could be used in other subjects (not only in mathematics).					
4	Tools have a good prospect for patent and commercialization					
5	Tools are recommended to be available in other platforms (not only for Windows operating system)					

Comment:
____

2) Interview for implementation evaluation

Guidelines for interviews were constructed to guide researcher in the conduct of interviews with teachers in regard to their experiences with the electronic mapping systems. The interview was conducted with individuals; however, it also was conducted in groups, if requested by teachers.

Table 3.20 Interview guideline

In the first part of the interview, teachers were remembered about electronic mapping system, its modifiable and shareable electronic maps, and its function to map resources in the internet and learning designs. 1. If you can create an electronic map, what electronic maps would you like to create? 2. How the electronic you created could be used to support teaching and learning? 3. What is your opinion about implementation of electronic mapping system in the area of Bojonegara Sub District, to enable teachers in this area to create and share electronic maps of resources in the internet and learning designs, so one teacher can use the others' electronic maps?

3.2.3.3 Data collection procedures

There were four stages to the implementation study. The first stage was preparation, the second stage was school visitations and the use of the electronic mapping system by teachers, and the third stage was software tools evaluation by the teachers.

1) Preparation

The preparation stage consisted of two parts packaging and ethics approval. The software package and its supporting documentation was burned to a CD (Compact Disc) from which the teachers could install the software and copy the electronic map template directly to their computers. Supporting documentation was provided on the CD and in print format so that teachers could easily read it. Ethics approval and requesting official permission to conduct the research from the Head,

Bojonegara Education Office, and 3) consultation with a Senior Head Master about the right time to visit schools in Bojonegara Sub District were also undertaken.

2) School Visitation

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. In the implementation phase of the 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 for the case studies, the researcher considered teacher ICT skills and their school ICT facilities. A demonstration of how to use the software was made to participating teachers, and they were then asked to follow up using the electronic mapping system in their own time and for their own purposes. No teachers tried the software at the same day of demonstration, because of their teaching schedule or because they did not bring their PC notebook to school that day.

3) Evaluation of the electronic mapping system by teachers

Following use of the software, each teacher, provided general information (genders, grade of teaching class, ownership and type of computers to be use in school and home) which was collected together with their satisfaction with the different components of the electronic map of learning resources and learning designs. Components were as provided in Table 3.21.

Table 3.21 Satisfaction components of electronic maps

Satisfaction components	
Electronic maps	**Associate reader of the electronic maps**
Mathematical Learning Resources	
1. Idea	1. Idea
2. File Structure	2. Layout of Software
3. Characteristics	3. Characteristics
4. Database Structure	4. Connection to Electronic Maps
5. Entry Data	5. Catalogue and Searching Facilities
6. Modifiable and Shareable ability	6. One button click to visit selected web site
7. Function	7. Function
8. Innovation	8. Innovation
9. Implementation	9. Implementation
Learning Designs	
1. Idea	1. Idea
2. File structure	2. Layout of software
3. Characteristics	3. Characteristics
4. Creating curriculum-aligned and non curriculum-aligned learning designs	4. Connection to electronic maps
5. Convert able to html	5. Using xml technologies
6. Modifiable and shareable ability	6. Record learning designs for each session
7. Function	7. Function
8. Innovation	8. Innovation
9. Implementation	9. Implementation

Teachers’ also evaluated components such as ease of use and appropriateness given current ICT facilities and the prospect for sustaining the use of the tools in the long run (refer Table 3.22).

Table 3.22 Evaluation components of electronic maps

Evaluation Components
1. Easy to use
2. Appropriate given current ICT
3. Beneficial for
Teachers
Students
School
Education office and community
4. Institutionalization
Implementation
Impact
Self-managed by teachers for a long term

Data collected from teachers, as explained in this section was then used for technology-based tool evaluation according to Alexander and Hedberg's (1994) evaluation model. The evaluation model for assessing the worth of innovation detailed by Alexander and Hedberg (1994) required evaluation at the four stages: 1) design, 2) development, 3) implementation, and 4) institutionalisation. In this thesis, the studies as discussed align with these four stages as represented in Table 3.23.

Table 3.23 Evaluation in Terms of the Alexander and Hedberg model

Purposes	**Evaluation Activities**
Phase 1 – Design	
Analysis of needs To inform decisions made in the design of the technology-based teaching and learning tools for use in developing countries	Localised investigations: Identification of the state of ICT in developing countries to provide information for planning of the development of technology-based teaching and learning tool 1. Questionnaires & interviews from 119 teachers regarding ICT for education in developing countries Bojonegara Sub District , Indonesia 2. Observation in Bojonegara Sub District , Indonesia
Phase 2 – Development To inform decision made in the development of the technology-based teaching and learning tools for use in developing countries	Development of Software tools 1. Analysis of technologies used in developing countries 2. Developer as researcher expertise complementing analysis of technologies available 3. Simulation of the use of software in different computers devices to test the program functionalities
Phase 3 – Implementation To determine the worth of the technology-based teaching and learning tool in the context of its	Implementation study to determine the impact of the technology-based teaching and learning tool in developing countries by gathering mathematics teachers'

use by teachers in developing countries	experiences use on electronic mapping system
Phase 4 – Institutionalise To determine usability and sustainability of the electronic mapping system	Institutionalisation of Innovation. Mathematics teachers' perceptions as to future use (Phase 3) led to further work to improve the usability and sustainability (maintenance evaluation) of the tools. Expanding usability involved: 1. Hyperlearning: Implementation of software for use by students in accessing resources 2. Mapping curriculum in Indonesian context 3. Curriculum review 4. Embedded learning support system 5. Documentation development and testing

Evaluation is not at an end point, but part of a cycle, and in this thesis project, after analysis of data provided by teachers, a decision was made to explore ways to the extend the use of the technology-based tools (See Chapter 5). Through extending the use of the technology-based tools developed during this research, the prospect for sustainable or institutionalisation becomes greater. Other researchers consider that for the implementation of ICT-based tools and integration both global and local challenges and possibilities need to be addressed (Dzvimbo, 2013).

3.2.4 Phase IV: Institutionalisation

Extending the usability and sustainability of the electronic mapping system, involved identifying additional applications so that it was more likely that the culture of use would grow and with it the greater chance of embedding its use. In this proposed extension of use, the use of the electronic mapping system was demonstrated in a study of students' use of hyperlearning, aligning the electronic mapping system to national curriculum in the Indonesian context, facilitating mathematics curriculum review using learning designs map, and facilitating the development of embedded learning support systems using the resource mapping tool. The exploration of usability, looked to the future using interviews of UOW staff from a Western, developed nation regarding improvements and extension of use they would like for the electronic mapping system to ensure institutionalisation and sustained use of

these tools. The Western context is different and at times the extended use required better infrastructure, but their views illuminated future directions.

3.2.4.1 Hyperlearning

> *In the next five years, instructional models will be better adapted to support the design and development of highly flexible learning scenarios and just-in-time/task performance and instructional supports. Indeed, this will be one outcome of recent interest in and emphasis on design research. Instructional models will become more flexible with regard to time, place, and content and will also allow richer varieties and mixes of learning support, including more support for guided and self-directed learning* (Tamara van Gog, Paas, et al, 2008, p. 810).

The inspiring statement above is in line with the development of an electronic mapping system that maps resources and learning designs. An electronic mapping system can enable teachers to provide an alternative teaching approach; by providing maps to internet accessible resources they are able to guide students' access to resources.

The incorporation of internet resources into classroom practice was implemented by Ruthven, Hennessy, and Deaney (2003). However this research project intended to incorporate the internet resources using electronic maps, designed and developed during this research project, to guide students to access mathematical learning resources on the internet. This practice also can be considered as part of E-learning. E-learning is the online delivery of information for purpose of education, training, or knowledge management (Turban, King, Mackay, et al, 2008, p. 376).

> *The e-learning may include the use of Web-based teaching materials and hypermedia in general, multimedia CD-ROMs, Web sites, discussion boards, collaborative software, emails, blogs, wikis, chat rooms, computer aided assessment, educational animation, simulation, games, learning management software, electronic voting system,*

> *and more, with possibly combination of different methods being used* (Turban, King, Mackay, et al, 2008, p. 376).

The internet technology revolution and the availability of learning resources have enabled people to learn beyond the traditional learning methods available prior to the spread of the internet. Learning it would seem has attained a new stage, a new dimension that is different from previous notions of learning. The term beyond, above, or over is the definition of *hyper* (Oxford Dictionaries), while *learning* is defined as the acquisition of knowledge or skills through study, experience or being taught (Oxford Dictionaries). Based on these definitions, *hyperlearning* can be defined as beyond learning. This term along with other variants such as *hyper-learning* and *hyperLearning* refer to aspects of learning, when and where that is different to previously used notions of learning. Hyperlearning can occur as a consequence of the emergence of new technologies.

The focus of this activity was investigation of the processes and learning outcomes. Hence, each student’s activities during the process of learning through each method were recorded. Four instruments were used: student demographics, process of learning, knowledge pre- and post-tests, and students’ evaluation and satisfaction.

a) Student demographics.

At the first joint meeting the *Demographic* questionnaire was completed by students. This questionnaire asked the students their age, gender, English skills and whether they had access to a computer and the internet. Both guided hyperlearning and unguided hyperlearning require computer and internet related skills.

b) Process of learning.

The questionnaire for topics taught by *guided* hyperlearning asked the students whether or not they used the electronic mapping system to access and uses the designated mathematical learning resources for each sub-topic (refer Table 3.24).

Table 3.24 Process of Learning - Guided Hyperlearning.

Subtopic	Electronic mapping system was Used to Access and Use the Designated Resources in The Internet		Comment (if needed)
	YES	NO	
1			
…			
5			

The questionnaire for topics taught by unguided hyperlearning asked for the lists of web addresses for the mathematical learning resources students accessed and used for learning the specific sub-topics (refer Table 3.25).

Table 3.25 Process of Learning - Unguided Hyperlearning.

Subtopic	Web Site Address of Learning Resources	Comment (if needed)
1		
…		
5		

For students in the conventional learning treatment the *Process of learning* questionnaire asked students to make a self-evaluation of the learning process for each subtopic (refer Table 3.26).

Table 3.26. Process of learning - Conventional Learning.

Subtopic	Self-Evaluation on Students Acquisition of Mathematical Learning Resources Provided in Group Through Conventional Learning (CL)				
	Excellent	Good	Fair	Poor	Bad
1					
…					
5					

c) Pre- and Post-test instruments.

Pre-test and post-test instruments were used to measure students' academic performance. The pre-test was completed before the learning phase. The pre-test and post-test instruments were not equivalent although they had had similar questions. The post-test after the learning phase had slightly more difficult questions. A list of pre-test and post-tests questions is enclosed in Appendix XIV.

d) Questionnaire of students' satisfaction and evaluation components

The questionnaire regarding students' satisfaction and evaluation was to enable a comparison of the three groups learning method treatments on components of satisfaction. The components of satisfaction (refer Table 3.27) are based on important aspects of learning, including access and quality of learning resources, designs of learning, interaction and its perceived benefits. Evaluation is based on implementation (easy to access and difficulty facing by students), hyperlearning condition, and the last is its appropriateness to ICT provisions.

Table 3.27. Satisfaction with and evaluation of mathematical learning resources.

No	Components	
	Satisfaction	Evaluation
1	Access to learning resources	Ease of access to learning resources
2	Quality of learning resources	Difficulty in use of the method
3	Design of learning	Supports students self-learning
4	Interaction between lecturer & students	Supports learning anywhere & anytime
5	Benefits	Appropriate to current ICT provisions

The empirical study required participants to access resources accessible via the internet using the technology-based tool provided by researcher. To do participants must have or at least have available access to internet-connected computer devices, such as notebook PC, desktop PC or the like wherever and whenever during the experiment. The most likely participants to have such technology access for this empirical study were university students in the area near to Bojonegara Sub District, Indonesia.

The design of this empirical study can be classified as quasi-experimental. According to Mertens (2010), quasi-experimental designs are those that are "almost" true experimental designs, except that the participants are not randomly assigned to groups, rather they are assigned to class automatically by a university educational information system. The lecturer specified each topic and subtopics to be learned. The topics *Number System*, *Functions*, and *Graphing* and subtopics all have different characteristics drawing on the cognitive domain, psychomotor domain or a combination of the two.

Table 3.28 Topics, Characteristics, and Subtopics.

Topic	Characteristics	Subtopics				
		1	2	3	4	5
Number	Cognitive	History of Number Systems	Natural Number	Rational Number	Arithmetic Operation	Special Topics
Functions	Combination of Cognitive and Psychomotor	Definition and examples	Operation	Composition of Functions	Special Functions	Graphs of Functions
Graphing	Psychomotor	Cartesian Coordinates (2-D)	Polar Coordinate (2-D)	Cartesian Coordinate (3-D)	Polar Coordinate (3-D)	Graphs with Parameters

Sub-topics in the number system belong to the cognitive domain, because the learning focus is on learning different forms of knowledge in the number system. Sub-topics in graphs belong to the psychomotor domain, because of the focus on students' ability and skills to construct graphs with pencil, rulers, or computers. The functions topic, involves combination of cognitive and psychomotor skills, because this topic focuses on both the learning of knowledge about functions,

and the students ability and skills to construct graphs of functions with pencil, rules, or computers.

3.2.4.2 Aligning technology-based tools to Indonesian national curriculum

Mathematics teachers were asked (see section 4.3) to use the technology-based tool developed to map resources and learning designs for their mathematics teaching and their students' learning. The teachers' attempt to use the technology-based tool to align their teaching with the Indonesian national curriculum is examined (refer Section 5.3). Providing ways in which the technology-based tool can be aligned to Indonesian national curriculum may increase the usability and sustainability of this tool in the future. Just as national curriculum reviews, as suggested Brundett (2011) may advantage to the nation, school and institutional reviews may advantage these institutions and students within them. In practice, the implementation of the learning design tools also can be aligned curriculum for mapping resources in form of electronic map that can be provided to teachers. In terms of technology-based tools, the ability to link to subsections of the documented curriculum is likely to be important.

3.2.4.3 Curriculum review

To explore the usability of the learning resource maps a demonstration is conducted to examine how the software tools can be used to review a mathematics curriculum and the issues that arise in such reviews. For purposes of the demonstration two subjects from the School of Mathematics and Applied Statistics, University of Wollongong (UOW) were mapped and then subjected to review. Implementation of the curriculum review is conducted by documenting learning designs data of each subject, then aggregating this data for use in curriculum review.

In this thesis, the curriculum mapping is developed in accordance with ideas of curriculum review (Absolum, 1995) in particular proposed by Kallick and Colosimo (2009), that there are five important aspects to curriculum mapping and assessment data to improve learning: 1) Creating a vision, 2) Curriculum mapping as a data source, 3) Assessment results as a data source, 4) Using an action plan to monitor processes, and 5) Technology as a source of curriculum evaluation. Mapping curricula is based on a vision of school and university. When each formal subject is mapped by each responsible educator and drawn together by the course co-ordinator resources and learning designs are combined and the results of the mapping allow analysis of whether or not these visions are being obtained (as represented in Figure 3.7).

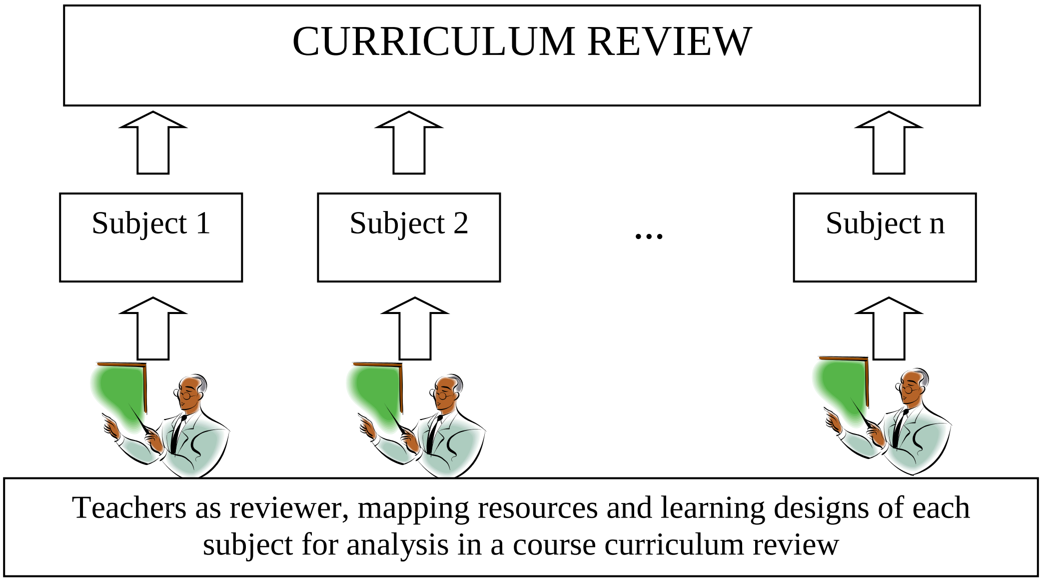


Figure 3.7 The Role of Teachers or Lecturers in Proposed Curriculum Review

3.2.4.4 Embedded learning support system

To explore expanding usability through facilitating embedded learning support system was developed. Other embedded learning support system have been produced for several subjects at UOW. These include the Summertime Math collection at http://www.math.uow.edu.au/subjects/summer/subjects/m151.html, however this type of resource required considerable html coding and resource development.

In this case, the technology-based tool, based on its feature of mapping resources accessible via the internet will be used to facilitate the development of an embedded

learning support system, for one tertiary mathematics subject covering the major topics areas. The resources included in the mapping align with these topics and all subtopics and the map links to web accessible video resources.

In Chapter 4 implementation of these studies and the ensuing results activities will be discussed.

CHAPTER 4. RESULTS

Having identified ICT tools this chapter is framed in terms of collecting and reporting the results of research activities, in accord with Alexander and Hedberg's(1994) model of evaluation for assessing the worth of innovation using: 1) Phase I: Localised study of ICT conditions, conducted through observation, interview and surveys with 119 teachers in Bojonegara Sub District, Indonesia, 2) Phase II: Development of software tools, 3) Phase III: Implementation of the software, gathering of 13 mathematics teachers' experiences of the implementation of the electronic mapping system in Bojonegara Sub District, Banten Province, Indonesia, and 4) Phase IV: Institutionalisation of innovations.

4.1 Phase I: Localised study of ICT conditions

Bojonegara is a Sub District of Banten Province, located in a coastal region of Java Island, Indonesia (refer Figure 4.1). The area, Bojonegara covers 30.30 km^2 and consists of 10 villages (Bojonegara, Karangkepuh, Kertasana, Lambangsari, Mangkunegara, Margagiri, Pakuncen, Pengarengan, Ukirsari, and Wanakarta). According to the population census in year 2005 by *Badan Pusat Statistik Provinsi Banten* (Indonesian Statistics Office of Banten Province, 2005), the number of population in this Sub District is 40,213 people (on average 1,327 people per km^2).

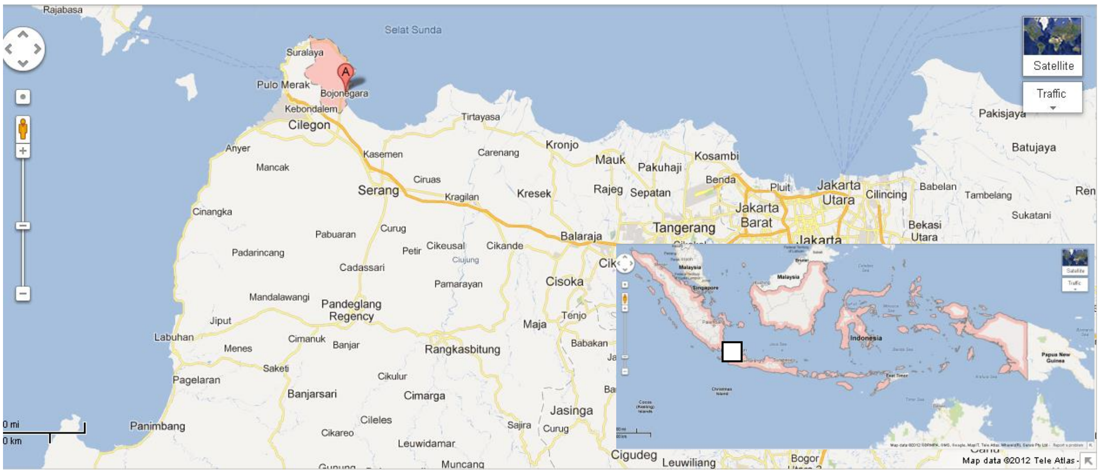


Figure 4.1 Location of Bojonegara Sub District, Banten Province, Indonesia

Geographically, rural areas dominate Bojonegara Sub District. As illustrated by photos (refer Figure 4.2) there are many rice paddies, along with clusters of people, houses and buildings, such as government buildings and schools.

Figure 4.2 Pictures of Bojonegara Sub District , Banten Province, Indonesia

4.1.1 Participants

The localised study was conducted between October 2010 and February 2011 with several weeks of break around the end of December and early of January. Ten headmasters welcomed and allowed the researcher to visit and document ICT infrastructure and facilities in their schools. Only two headmasters did not allow the researcher access to the school or teachers. A total of 220 questionnaire packages were distributed to teachers in elementary, junior and senior secondary school. Over the three school levels a total number of 119 teachers completed and returned the questionnaires (refer Table 4.1), giving a response rate of 54 per cent.

Table 4.1 School level of respondents

	Frequency	Percent
Elementary School	41	34.5
Junior Secondary School	51	42.9
Senior Secondary School	27	22.7
Total	119	100.0

The numbers of teachers as respondents is not exactly same as sought when the sample composition was calculated, with less responding from the elementary school and senior secondary school level, and more responding from junior secondary school level as presented in the Table 4.2. The variation from that intended was reasonable in terms of providing groups near 30 teachers and the responses considered viable numbers in terms of representing school ICT conditions.

Table 4.2 Comparison of expected number and the real number of participants

School level	Expected to Participate	Participated	Difference
Elementary School	45	41	- 4
Junior Secondary School	39	51	+ 12
Senior Secondary School	39	27	- 12
Total	123	119	- 4

The teachers were considered to be participants if they either fully or partially completed the questionnaire then returned it to the researcher. In addition, a total of 12 teachers (some of them completed questionnaire and some did not) agreed to be interviewed, with five of these interviews video recorded. At each school level the respondents are predominantly female (refer Table 4.3) and this is in accord with a greater proportion of teachers being female. Approximately 65 per cent of respondents were female.

Table 4.3 School level and gender of respondents

	Female		Male		Total
	n	%	n	%	n
Elementary School	27	65.9	14	34.1	41
Junior Secondary School	35	68.6	16	31.4	51
Senior Secondary School	15	55.6	12	44.4	27
Total	77	64.7	42	35.3	119

The teachers' years of teaching experience is presented in Table 4.4. Notably, approximately 80 per cent of the respondents had more than three years experience. While 43 per cent have 4 to 10 years working experiences. Indeed only 14.6 per cent of elementary teachers are in their first three years of teaching, although this increases to 20.6 per cent junior secondary and 29.6 per cent of senior secondary teachers. Based on this data, most respondents can be classified as experienced, senior teachers.

Table 4.4 Teachers Working Experiences

	0-3 years		4-10 years		11-20 years		21- 30 years		>30 years		Total
School Level	n	%	n	%	n	%	n	%	n	%	n
Elementary	6	14.6	10	24.2	7	17.1	10	24.4	8	19.5	41
Junior Secondary	8	20.5	24	61.5	6	15.4	1	2.6	0	0	39
Senior Secondary	8	29.6	12	44.4	6	22.2	0	11	1	3.7	27
Total	22	20.6	46	43.0	19	17.8	11	10.3	9	8.4	107

Since the participants surveyed and interviewed were predominantly experienced teachers, it is assumed they are more likely to know the state of ICT than the newer teachers and as such the information gathered represents the real conditions in Bojonegara Sub District. Data provided by teachers, regarding the ICT conditions in Bojonegara Sub District was considered the primary data but this was cross checked and validated by the researcher visiting and documenting (photos and video) ICT infrastructure, facilities and resources in the area and schools.

In terms of teachers experience it was determined that 83.1 per cent of teachers hold a bachelor degree suggesting these were capable teachers at least in accordance with the Indonesian national law regarding teachers and lecturers. These law states that

the minimum academic degree for a teacher is a bachelors' degree, and the minimum academic degree for a lecturer is a master degree (refer Table 4.5).

Table 4.5 Teachers Academic Degree

	Secondary		Diploma		Bachelor		Post-Graduate		Total
School Level	n	%	n	%	n	%	n	%	n
Elementary	5	12.2	6	14.6	30	73.2	0	0	41
Junior Secondary	1	2.0	2	4.0	44	88.0	3	6.0	50
Senior Secondary	1	3.7	1	3.7	24	88.9	1	3.7	27
Total	7	5.9	9	7.6	98	83.1	4	3.4	118

Furthermore, Table 4.6 also reveals that 72 per cent of the teachers surveyed held a degree in education.

Table 4.6 Teachers fields of academic degree

	Social or Economics		IT or computers		Sciences		Education		Other		Total
School Level	n	%	n	%	n	%	n	%	n	%	n
Elementary	1	2.4	0	0.0	0	0.0	34	82.9	6	14.6	41
Junior Secondary	4	8.0	0	0.0	1	2.0	38	76.0	7	14.0	50
Senior Secondary	3	11.1	3	11.1	3	11.1	13	48.1	5	18.5	27
Total	8	6.8	3	2.5	4	3.4	85	72.0	18	15.3	118

As this study is concerned with ICT, the number of teachers trained in relation to ICT was explored as this relates to teachers ICT skills. As can be seen in the previous Table 4.6 only a very small percentage of teachers (2.5%) and all from the senior secondary school had been trained in the ICT field.

Table 4.7 Teachers experience on attending ICT related training

	Never		1-2 times		3-5 times		> 5 times		Total
School Level	n	%	n	%	n	%	n	%	n
Elementary	30	73.2	8	19.5	1	2.4	2	4.9	41
Junior Secondary	9	23.1	17	43.6	12	30.8	1	2.6	39
Senior Secondary	11	40.7	13	48.1	2	7.4	1	3.7	27
Total	50	46.7	38	35.5	15	14.0	4	3.7	107

Although the official educational background of teachers is good, their training, attending or participating in ICT related training is still low. As displayed in Table 4.8, in total only 3.7 per cent teachers have more than 5 training experiences related to ICT, and only 14 per cent of them have 3 to 5 training experiences related to ICT. This finding suggests that the teachers ICT skills may be poor. If there are many teachers in Bojonegara Sub District with good ICT skills, it would be because of their self-interest and experiences with ICT, and not because of the official training conducted by schools or the Education Office. This finding in fact can be used as a basis for recommending the Education Office conduct a number of ICT related training programs for teachers in Bojonegara Sub District, Banten Province, Indonesia.

4.1.2 ICT conditions

There are various levels at which ICT conditions can be examined, in the sub district, at the school, and the home levels.

1) In the sub District

In recent years, a substantial amount of ICT infrastructure and facilities have been developed in this region of Banten Province. Base transceiver station (BTS) towers, constructed in this region, now deliver wireless signals for hand phones and internet connection, enhancing communication both within and outside the school district (refer Figure 4.3).

Figure 4.3 Location of BTS Towers near Schools

2) At the school level

In elementary schools, computer and related facilities are only used for administrative purposes, such as writing letters or administration reports; they are not used for teaching and learning. The equipment is supplied by the Education Office for school administration purposes not to support teaching and learning processes. All elementary schools visited during observation had TV and related electric equipment (such as CD/DVD players, refer Figure 4.4 for a typical set up).

Figure 4.4 Computer and other ICT Facilities

In junior and senior high schools, observation revealed that 66.7 per cent of the sampled schools had one computer laboratory for teaching and learning. Teachers through the questionnaire as displayed in Table 4.8 revealed a similar percentage of schools containing at least one laboratory.

Table 4.8 Computer laboratory at schools

School level	No computer laboratory		Computer Laboratory		Total
	n	%	n	%	n
Elementary School	41	100	0	0	41
Junior Secondary School	0	0	51	100	51
Senior Secondary School	0	0	27	100	27
Total	41	34.5	78	65.5	119

Where computer laboratories are used the usage is not high. As indicated in Table 4.9 there is no computer laboratory use for teaching and learning at elementary school, in junior school only 6.5 per cent of teachers using the computer lab 3-5 times per month and in senior secondary this use is by 5.3 per cent of teachers.

Table 4.9. School level and teachers' use of computer laboratories

	No		1-2 times per month		3-5 times per month		Total
School Level	n	%	n	%	n	%	n
Elementary	41	100	0	0	0	0	41
Junior Secondary	20	64.5	9	29.0	2	6.5	31
Senior Secondary	15	78.9	3	15.8	1	5.3	19
Total	76	83.5	12	13.2	3	3.3	91

Results of interview and photo documentation confirmed junior and secondary schools usually have a computer laboratory with typical layout as displayed in Figure 4.5.

Figure 4.5 Computer laboratories

Some classes are also equipped with TV. However as determined by the visits and interviews, the TV was rarely used by teachers.

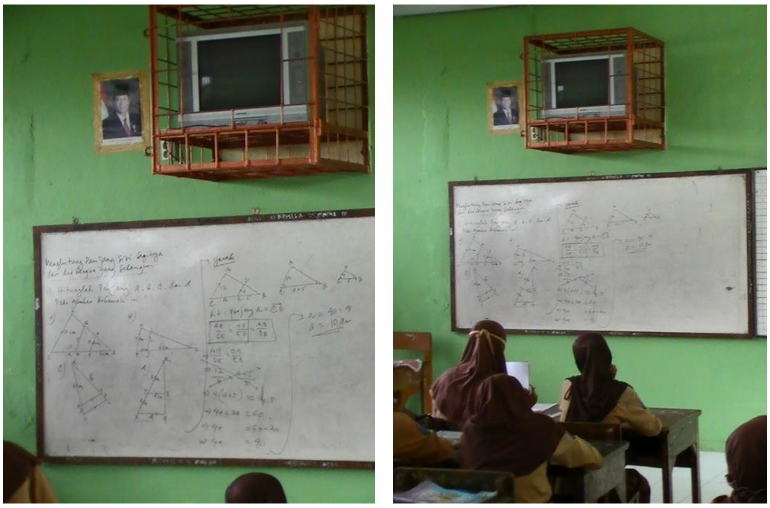


Figure 4.6 Typical classroom set up for TV use

According to the interviews, state schools received these computers, electronic resources, and related devices from the government. Private schools receive a donation from students' parents or grants from their founders. At least until these data were collected, although there are many private companies (some of them are foreign companies and manufacturing factories) in Bojonegara Sub District, schools in this area received neither grant or benefit from these companies for ICT infrastructure, facilities, and resources. There is an opportunity for the government to encourage companies as part of their Corporate Social Responsibility (CSR) to consider giving educational grants to schools, by giving ICT facilities to schools or by providing support in the form of scholarships for poor students. CSR is mandated for good corporate governance, and should be implemented by these companies, because they are located near enough to schools and rich enough to do it.

At elementary schools, computers, printers, and other electronic equipment are only for use for administrative purposes, not for teaching and learning. Students learn in the class with conventional teaching and learning processes involving teacher instruction at the whiteboard. However at junior and secondary school, the computer laboratories are available. Although in some schools the number of computers in the computer laboratory is not more than 20 units, whereas class size is 30 to 40 students, still their condition is good and they can be used for teaching and learning. Observation indicated there was internet access (wireless) in the junior and senior high schools, and although the speed of the internet access was not good, it was still convenient to use for accessing web sites for searching and downloading learning resources from the internet. The researcher also observed one teacher accessing a social network account during the visit using a notebook connected to the internet, a further indication of use of the internet.

Notebooks (portable computers) or projectors are available at each school level. All junior secondary teachers had access to a notebook and computer in their school, however approximately 30 per cent of teachers in elementary and senior secondary school reported that they did not have access to these notebooks and

projectors (refer Table 4.10). This may have happened due to limitations in the number of notebooks and projectors.

Table 4.10 Teachers' access to schools' notebook and projectors

School level	No access		Access available		Total
	n	%	n	%	n
Elementary School	29	70.7	12	29.3	41
Junior Secondary School	0	0	39	100.0	39
Senior Secondary School	19	70.4	8	29.6	27
Total	48	44.9	59	55.1	107

Although notebooks are available 87.2 per cent of teachers (refer Table 4.11) stated that they did not use it for teaching and learning.

Table 4.11. The use of computer notebooks or projectors for teaching and learning

	No		1-2 times per month		3-5 times per month		6-10 times per month		Total
School Level	n	%	n	%	n	%	n	%	n
Elementary	29	100.0	0	0.0	0	0.0	0	0.0	29
Junior Secondary	22	71.0	5	16.1	3	9.7	1	3.2	31
Senior Secondary	24	92.3	2	7.7	0	0.0	0	0.0	26
Total	75	87.2	7	8.1	3	3.5	1	1.2	86

In terms of internet access, this facility is only available to teachers in junior and senior secondary schools (refer Table 4.12). Observation confirmed this internet access with the researcher detecting the wifi signal and observing teachers connect their own notebooks to the internet using school provided connections.

Table 4.12 Teachers' internet access through the school

School level	No access		Access available		Total
	n	%	n	%	n
Elementary School	41	100.0	0	0.0	41
Junior Secondary School	11	28.2	28	71.8	39
Senior Secondary School	19	70.4	8	29.6	27
Total	71	66.4	36	33.6	107

Although the internet was available in junior and senior high schools, questionnaire results reveals that 80.6% of junior and secondary school levels teachers did not use internet for teaching and learning (refer Table 4.13).

Table 4.13. School levels and the teachers' use of internet for teaching and learning

	No		1-2 times per month		3-5 times per month		6-10 times per month		Total
School Level	n	%	n	%	n	%	n	%	n
Elementary	41	100.0	0	0.0	0	0.0	0	0.0	41
Junior Secondary	26	74.3	7	20.0	1	2.9	1	2.9	35
Senior Secondary	24	88.9	2	7.4	0	0.0	1	3.7	27
Total	91	88.3	9	8.7	1	1.0	2	1.9	103

Teachers reported using their personal mobile phone in the school for internet access (refer Table 4.14). The interviews, in accord with the questionnaires also reveal that several teachers have an internet connection from their own mobile phone and frequently access the internet using them. They know that the internet is useful and they know how to use it.

Table 4.14. School level and teachers' internet access using mobile phone

School level	No access		Access available		Total
	n	%	n	%	n
Elementary School	21	91.3	2	8.7	23
Junior Secondary School	15	39.5	23	60.5	38
Senior Secondary School	7	25.9	20	74.1	27
Total	43	48.9	45	51.1	88

In addition, 18.8 per cent of teachers frequently access the internet using their mobile phones more than five times a day in the school. The access is for personal use.

Table 4.15. School level and number of teacher internet accesses with mobile phones

School Level	No		1-2 times per day		3-5 times per day		> 5 times per day		Total
	n	%	n	%	n	%	n	%	n
Elementary	12	85.7	2	14.3	0	0.0	0	0.0	14
Junior Secondary	1	5.9	8	47.1	1	5.9	7	41.2	17
Senior Secondary	6	35.3	6	35.3	3	17.6	2	11.8	17
Total	19	39.6	16	33.3	4	8.3	9	18.8	46

Fifty-one percent of teachers used their mobile phones to access the internet. These finding suggest that teachers are familiar with the internet, and are thus able and interested in accessing internet although they were on working days at school. With these skills and internet access at least at the high school level, it is possible that teachers could be supported to use resources on the internet for teaching and learning.

As indicated in Table 4.16, in total only 15 per cent of teachers stated that there is an official web site or blog for their school. However all of these teachers stated that these official web sites or blogs are not used to support teaching and learning experiences.

Table 4.16. School level and the official web site or blog

School level	No official website of blog		Official website or blog is available		Total
	n	%	N	%	n
Elementary School	41	100.0	0	0.0	41
Junior Secondary School	33	84.6	6	15.4	39
Senior Secondary School	17	63.0	10	37.0	27
Total	91	85.0	16	15.0	107

The researcher had attempted to access these official websites or blogs to confirm their existence and found the main purpose of schools' website or blog is only to broadcast schools' basic information, statistics, teacher composition, and some schools activities for the public and all is in the Indonesian language (refer Figure 4.7). It is likely that the schools' official websites or blogs are

initiated by one or two teachers who are interested or who have good computer and internet skills.

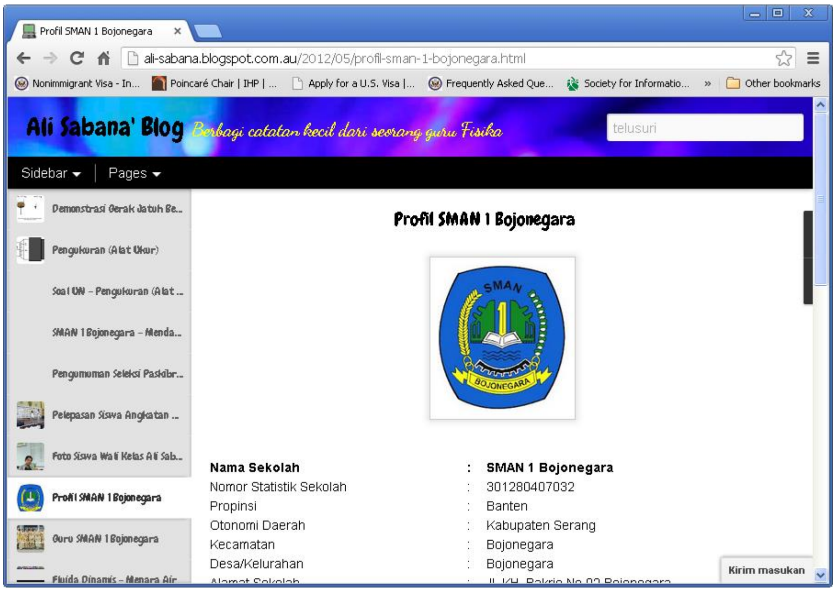


Figure 4.7 An example of schools' website or blog

The usability of ICT at schools depends upon it being maintained and serviced during technical problems that can occur during use. For this reason, there should be one or more IT staff, whether officially employed in the school or by another company, such as computer service shop.

Table 4.17. School levels and the availability of IT staff

School level	No IT staff		IT Staff available		Total
	n	%	n	%	n
Elementary School	41	100.0	0	0.0	41
Junior Secondary School	20	51.3	19	48.7	39
Senior Secondary School	9	33.3	18	66.7	27
Total	70	65.4	37	34.6	107

There is no IT staff at elementary schools nor visits by IT professionals, while in total 56.1 percent teachers of junior and senior secondary staff stated that IT

staff is available. In junior and secondary high-school, 24.2 per cent of teachers indicated that IT staff visit only 1 or 2 times per month, while 31.8 cent stated that IT staff visit schools more than 10 times per month (refer Table 4.18).

Table 4.18. School levels and the number of visit of IT staff

	No		1-2 times per month		> 10 times per month		Total
School Level	n	%	n	%	n	%	n
Elementary	41	100.0	0	0.0	0	0.0	41
Junior Secondary	20	51.3	6	15.4	13	33.3	39
Senior Secondary	9	33.3	10	37.0	8	29.6	27
Total	70	65.4	16	15.0	21	19.6	107

3) At the teachers' home

In contrast to the availability of technology in schools, the highest percentage of teachers who have computers at home are the elementary teachers (82.5%) with the least number of computers at home reported by junior secondary (72.2%) and then the senior secondary teacher (64%). Further results, in regard to available computer and related devices and services are displayed in Table 4.19.

Table 4.19 Available computer and related devices & services

At home	Elementary		Junior Secondary		Senior Secondary	
	n	%	n	%	n	%
Computer	33	82.5	26	72.2	16	64.0
Printers & Scanners	28	70.0	20	55.6	14	56.0
Internet Access	1	2.5	13	35.1	18	30.8
Personal Website or Blog	0	0.0	2	6.5	5	20.8
Phone internet Access	6	15.0	27	79.4	12	63.2
IT assistance	27	67.5	18	52.9	18	81.8

The number of teachers who use their own computer at home for preparation of teaching and learning is low (refer Table 4.20) particularly for elementary teachers, 96.4 percent of whom never use the home computer for teaching and learning. Teachers' use of their own computers for teaching and learning includes the preparation of learning resources, learning designs, tasks,

downloading learning materials from internet. The findings show that the teachers of senior and junior secondary schools are more familiar with the use of computer for teaching and learning than teachers in elementary schools.

Table 4.20. The use of computers for teaching and learning

At home	Elementary		Junior Secondary		Senior Secondary		Total
	n	%	n	%	n	%	%
Computer							
Never	27	96.4	6	30.0	1	7.7	55.7
1-2 times per month	1	3.6	8	40.0	5	38.5	23.0
3-5 times per month	0	0.0	5	25.0	1	7.7	9.8
6-10 times per month	0	0.0	1	5.0	1	7.7	3.3
> 10 times per month	0	0.0	0	0.0	5	38.5	8.2

In accord with the questionnaire, those staff interviewed confirmed that the majority of teachers have their own computer at home. Teachers stated that their computer at home is used by their family, usually their children, for many purposes such as for playing PC games, watching movies, and other fun activities. The price of a set of desktop computer today, in Indonesia normally priced Rp 3,649,000 to Rp 14,608,000 or around AUD $394 to AUD $1579 (Bhinneka, 2013). Some teachers also indicated that they have a computer notebook, in Indonesia normally priced around Rp 2,609,400 to Rp 32,219,000 or around AUD $282 to AUD $3,483 (Bhinneka, 2013). This range of prices is affordable for many public servant teachers whose base annual salary for new teachers with no professional teaching experience or service is Rp 28,423,200 or AUD $3,072 and senior teachers with 32 years or more professional teaching experience or service is Rp 65,026,000 or AUD $7,029 per year (Sekretariat Negara Republik Indonesia, 2013). This range is lower than annual salary of teachers in developed countries, for example in Australia, four-year trained teacher start on salary A $59,706 and the most experienced classroom teachers earning AUD$89,050 (NSW Department of Education and Communities, 2013).

For many public servant teachers in Indonesia, the prices of computer and related equipment are affordable. Approximately 20 per cent teachers bring the computer notebook to the school for their own purposes. Although the number of teachers who have printer or scanner is less than those who own computers, in total the 61.4 per cent of teachers have their own printer or scanner. Despite the large number of teachers (n=55, 61.4%), who have their own printer or scanner, only 31.8 (n=23) percent use it to support teaching and learning. These and other findings suggest there is a potential to support teachers' use of their home computer for teaching and learning.

Table 4.21. The use of printer and scanner for teaching and learning

At home	Elementary		Junior Secondary		Senior Secondary		Total
	n	%	n	%	n	%	%
Printer & Scanner							
Never	26	96.3	6	35.3	0	0.0	58.2
1-2 times per month	1	3.7	8	47.1	3	27.3	21.8
3-5 times per month	0	0.0	3	17.6	3	27.3	10.9
6-10 times per month	0	0.0	0	0.0	0	0.0	0.0
> 10 times per month	0	0.0	0	0.0	5	45.5	9.1

The number of teachers who have and use internet access and phone internet access for teaching and learning is low (refer Table 4.22) particularly for elementary teachers who never use internet access and phone internet access for teaching and learning. Teachers' use of internet access and phone internet access for teaching and learning are for activities such as downloading learning materials from internet, searching educational articles to learn how to improve their teaching and learning. The findings show that the teachers of senior and junior secondary schools are more familiar with the use of computer for teaching and learning than teachers in elementary schools.

Twenty-one per cent of teachers, all but one secondary teacher has internet access at home (refer Table 4.22). The teachers of senior and junior secondary schools are more familiar with the use of internet for teaching and learning with none of the elementary teachers using their home internet for teaching and learning purposes. Of the teachers who have the internet at home only around 25

per cent, use it for teaching and learning purposes, however it is possible that teachers can be supported to take advantage of the resources on the internet for teaching and learning. At home, 48.4 per cent of teachers access the internet using their mobile phone, and the number of them who frequently access the internet using mobile phone is also large, up to 59.1 per cent.

Table 4.22. The use of internet for teaching and learning

At home	Elementary		Junior Secondary		Senior Secondary		Total
	n	%	n	%	n	%	%
Internet access							
Never	21	100.0	5	55.6	1	16.7	75.0
1-2 times per month	0	0.0	2	22.2	1	16.7	8.3
3-5 times per month	0	0.0	1	11.1	2	33.3	8.3
6-10 times per month	0	0.0	0	0.0	0	0.0	0.0
> 10 times per month	0	0.0	1	11.1	2	33.3	8.3
Phone internet access							
Never	13	72.2	3	12.5	1	7.7	30.9
1-2 times per day	5	27.8	12	50.0	8	61.5	45.5
3-5 times per day	0	0.0	1	4.2	3	23.1	7.1
> 5 times per day	0	0.0	8	33.3	1	7.7	16.4

The number of teachers who have and use personal website or blogs for teaching and learning is low (refer Table 4.23). The findings show that only one teacher from junior secondary schools and two teachers from senior secondary school confirmed experience with the use of a personal website or blogs for teaching and learning.

Only a small number (7.4%) of teachers have a personal web site or blog, however the use of personal web sites or blogs for teaching and learning is negligible. Only three teachers (15%) of those who had a blog or personal website used these for school purposes (refer Table 4.23).

Table 4.23. The use of personal website or blogs and IT assistance

At home	Elementary		Junior Secondary		Senior Secondary		Total
	n	%	n	%	n	%	%
Personal website or blogs							
Never	12	100.0	4	80.0	1	33.3	85.0
Only once	0	0.0	1	20.0	1	33.3	10.0
Several times	0	0.0	0	0.0	1	33.3	5.0

IT assistance is important in order to support teachers working with computer at home. Only 55 (46.2%) of teachers have IT assistance at home. Regarding IT assistance at home, this is probably from family member s or computer shops near to teachers' homes. Of the total 55 teachers that stated that IT assistance is available at home, 41 (74.5%) indicate that there is no schedule for this assistance.

Table 4.24. IT assistance at home

At home	Elementary		Junior Secondary		Senior Secondary		Total	Total
	n	%	n	%	n	%	n	%
IT assistance								
No schedule	14	77.8	14	70.0	13	76.5	41	74.5
1-2 times per week	4	22.2	6	30.0	3	17.6	13	23.6
Everyday available	0	0.0	0	0.0	1	5.9	1	1.9

4.1.3 Learning resources and learning designs

Teachers and students can freely use *Buku Sekolah Elektronik (BSE)* that is Electronic School Books (refer Figure 4.8).

Figure 4.8 A screenshot of electronic school books

These electronic books are available in PDF format. There are several books that can be used by students and teachers from Class I, the first stage of formal education in Elementary Schools to Class XII, the last stage of Senior High School before university level. The Ministry of Education and Culture owns the copyright to these books and the contents are evaluated and monitored by the Ministry of Education and Culture. Teachers revealed in the interviews that they did not use them for teaching and learning. Some did not have or know about these books. Teachers might not consider the information in these books to be effective.

Several schools also have supporting media for teaching and learning such as educational CD/DVDs or software. Teachers can use these educational CD/DVDs or software if they need to (refer Figure 4.9).

Figure 4.9 Sample of available CD and Cassettes

Several senior and junior secondary schools have their own notebooks. According to interview, teachers stated that around 20 percent of teachers in their schools bring it to the school for their own purposes. Teachers also explained that they and their fellow teachers use the internet to download educational content for use in teaching and learning. The internet is sometimes their alternative source of teaching materials as they locate many internet available resources that are useful for their teaching.

4.1.4 Exploring possibilities: finding from teachers

Teachers were asked about the possibility of them implementing technology-based mathematical learning resources, through the internet or online platform in their school or class. As indicated in Table 4.25, 53.1 percent of junior secondary teachers and 23.5 percent teachers of senior secondary schools believe that the implementation is possible, however all, elementary school teachers considered that the implementation of learning resources “may be possible but it would be difficult”.

Table 4.25 Possible implementation of learning resources based on the internet

	Impossible		Maybe but it would difficult		Possible		Total
School Level	n	%	n	%	n	%	n
Elementary	0	0.0	31	100.0	0	0.0	31
Junior Secondary	2	6.3	13	40.6	17	53.1	32
Senior Secondary	2	11.8	11	64.7	4	23.5	17
Total	4	5.0	55	68.8	21	26.3	80

With respect to the implementation of learning designs, through the internet, the questionnaire revealed that the implementation may be possible, with none considering it to be impossible, but it would be difficult.

Table 4.26 Possible implementation of learning design based on the internet

	Impossible		Maybe but it would difficult		Possible		Total
School Level	n	%	n	%	n	%	n
Elementary	0	0.0	26	100.0	13	0.0	39
Junior Secondary	0	0.0	9	69.2	4	30.8	13
Senior Secondary	0	0.0	6	66.7	3	33.3	9
Total	0	0.0	41	67.2	20	32.8	61

These results are confirmed through interview with teachers. However teachers stated that the condition of ICT in their schools is problematic when it comes to the implementation of technology-based teaching and learning. One of teachers in the interviews stated that in general many teachers have good skills and are interested in implementing technology in the teaching and learning, including the integration of the internet to improve the quality of teaching and learning, however ICT infrastructure and facilities, such as the quantity and quality of available computers for teaching and learning, the lack of sufficient supporting equipment, such as projectors, the quality of internet access, software, and financial support required would make proper implementation of technology-based teaching and learning difficult. Other teachers interviewed made similar statements.

In general teachers stated that poor ICT conditions is the main problem for the implementation of technology-based teaching and learning in Bojonegara Sub

District, although they believe that the teachers have good computer skills, and are able to operate computers and other facilities for teaching and learning.

The observer/researcher saw that one of the problems related to a mindset of teachers that the computers, related equipment, and internet access must be available before the implementation of technology-based teaching and learning. This meant that teachers did not try to or know how to optimize their use of the limited ICT for teaching and learning under the current ICT conditions. There were possibilities to support teaching and learning, or in general to improve the learning experiences of students using the current condition of ICT even though the ICT conditions in their school were poor.

The researcher/observer was seeking ways maximize the impact of ICT on teaching and learning given the current condition of ICT infrastructure and facilities, such as computers, the related equipment and internet access in schools and teachers' homes, to improve students' learning experiences, especially in mathematics, without having to request an additional infrastructure, facilities, and resources that would be costly for schools or government. This thinking lead to the development of tools related to the technology-based teaching and learning, appropriate to current ICT conditions, but tools that could contribute toward improving learning experiences. When examining the desire or willingness for teachers to create and share both resources and learning designs, seventy four per cent of teachers indicated that they had experienced creating or modifying learning resources (refer Table 4.27).

For learning designs, only 19.3 percent of teachers have tried to initiate learning designs in the classroom or school. In the case of sharing of learning resources and learning designs, as revealed in Table 4.27, 27.4 percent of teachers wish to share their own learning resources, compared to 93.3 percent of teachers who wish to share their learning design.

Table 4.27 Experiences creating and sharing resources and learning designs

Experience	Elementary n	Elementary %	Junior Secondary n	Junior Secondary %	Senior Secondary n	Senior Secondary %	Total %
Created & Modified resources	33	82.5	10	76.9	6	46.2	74.2
Initiated learning designs	1	3.1	5	41.7	5	38.5	19.3
Created resources for internet/online	0	0.0	6	100.0	1	16.7	29.2
Wish to share own resources	5	15.6	7	46.7	5	33.3	27.4
Wish to share learning designs	38	100.0	12	85.7	6	75.0	93.3
Wish to use others learning designs	21	100.0	13	92.9	4	44.4	86.4

The researcher also asked teachers about whether they had experiences creating or modifying digital learning resources for use through the internet or online. With respect to the use of learning design, 86.4 percent of teachers stated that they wish to use other teachers learning design, with only a few teachers experienced in creating digital learning resources. Teachers also wanted to use other teachers' learning designs, with few teachers creating their own designs; therefore the circulation of a good learning design between teachers appears warranted.

This finding became the foundation for the mapping learning design for circulation by one teacher to other teachers and complementing this the mapping of internet accessible learning resources for use by teachers.. In terms of establishing what teachers need, it was determined from these interviews that:

1) The tools should relate to sharing mathematical learning resources and learning designs.
2) The technology proposed also should be related to the internet, since the internet has unlimited opportunity and options for enhancing and improving learning experiences, and also the internet provided the ability to share between teachers, and this is necessary to allow the tool to be widely used by other teachers. Thus the mapping of mathematical learning

resources on the internet and the mapping of learning designs were considered to be the most appropriate way support these teachers in the use of technology

4.1.5 Conclusion

Based on the results of observation, several important findings about the physical state and teachers' awareness of ICT infrastructures, facilities, and resources were gathered. Teachers' access and use of the internet to gather educational content for use in teaching and learning has been explored. The internet is one of the sources of learning resources, however because there are many learning resources in the internet, one potential way of assisting teachers especially for teaching and learning in Bojonegara Sub District involves mapping the relevant educational contents of learning resources in the internet.

Since the teachers wish to use other teachers learning designs and have little experience in creating learning designs, it is appropriate to develop tools that assist the circulation of good learning designs between teachers. This finding became the foundation for the mapping of learning resources on the internet for use by teachers, and the mapping of learning designs for circulation from one teacher to other teachers.

4.2 Phase II: Development of software tools

In this section, the development of software electronic mapping system that encompasses both mathematical learning resources and learning design is discussed. The development processes for the mapping tools to facilitate the development and sharing of the work of others followed the process for developing computer software as explained in Jalote (2005, p. 86). The process consisted of: 1) Analysis of requirements; 2) Design of software; 3) Coding; and, 4) Testing. A Windows

Operating System environment was chosen as the development platform as it is widely available in developing countries.

4.2.1 Analysis of requirements

Prior to the development of computer software, an analysis of requirements was undertaken. The analysis of requirements determined: 1) the capability needed by users to solve a problem or achieve an objective; and, 2) the capability that must be met or possessed by a system (Institute of Electrical and Electronics Engineer (IEEE) cited, Jalote 2005, p.80).

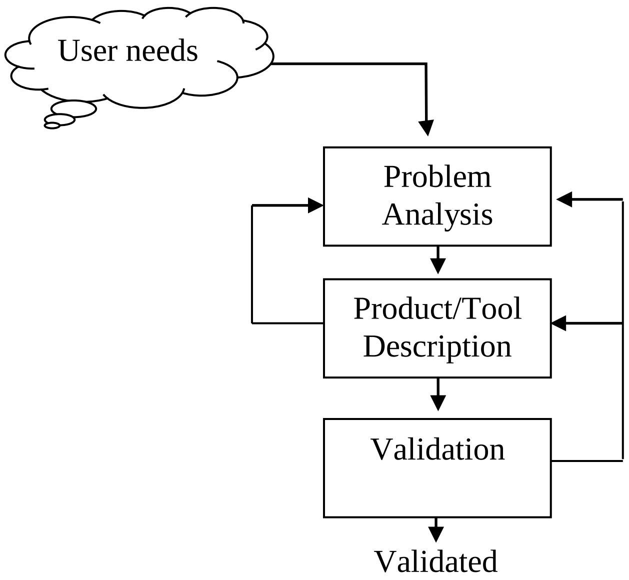


Figure 4.10 The requirement process (adopted from Jalote (2005, p. 86))

As illustrated in Figure 4.10, identifying user needs is the start of the analysis of requirements, and this is then followed by problem analysis, tool description, and validation in terms of satisfying user needs. Through this process, the proposed tool or tool is validated through satisfying user needs. That is an existing problem is solved theoretically through the provision of tool descriptions and validation, prior to implementation as solution satisfying user needs. Results of this initial analysis form the rationale for mapping tool development.

4.2.1.1 User needs

The analysis of needs, as discussed in sections 4.1.4 and 4.1.5, teachers believe accessing resources from the internet for use in teaching and learning is beneficial, however their experience is that there are too many learning resources on the internet for teachers. Teachers perceived they are limited in terms of time to make informed decisions about most available resources. In addition, the internet contains hidden resources or ones that cannot be accessed by search engines but which are accessible with directly providing web addresses. Sherman (2002) refers to these hidden resources as the invisible web. Approximately 20 per cent of teachers surveyed in this study were found to access and use the internet to gather educational content for use in teaching and learning and many more would like to.

Given that teachers are willing to share their mathematical teaching and learning experiences with other teachers, it was deemed possible and important to provide appropriate technology to support teachers prepared to share their learning designs. Further as there are many mathematical learning resources in the internet, one way of assisting teachers to find teaching and learning resources involves mapping the educational content of mathematical learning resources in the internet. Electronic maps as a file provide a medium suitable for mapping and facilitating the sharing of appropriate resources between teachers. Appropriate resources include learning designs maps that can be developed to document and share mathematics teaching and learning experiences. Since the teachers would like to use other teachers learning designs and such exchanges are likely to improve teaching and learning, it is important that circulation of maps of learning designs between teachers be facilitated.

4.2.1.2 Problem analysis

Analysis of data from a sample of 119 teachers in Indonesia Section 4.1.3 revealed that teachers need an appropriate approach, software, or system that is consistent with ICT capabilities in their area. These needs reflect the use of their own computers, and do not simply rely on their school or institutional ICT infrastructure

that would in a developing country would be considered inadequate. The software proposed is intended to support teachers in accessing many mathematical learning resources on the internet and to support teachers documenting and sharing their learning designs with others.

4.2.1.3 Tools description: concept of electronic mapping system

The proposed development had two main foci, 1) Mapping mathematical learning resources on the internet and 2) Documenting and sharing learning designs. To reflect the two foci and associated different mapping characteristics the proposed development was implemented in two separate products. The mapping of resources involved information about these resources on the internet (for example, name, URL),, whereas the mapping of learning designs is the detailed data (for example, task, resources, and supports). The purpose of each map is different, resources relating to accessibility, and learning designs to documentation of experiences, so the types of database used for each map is different, hence two distinct windows-based tools were developed for each mapping system. However, the conceptual basis for the two products is similar. Mapping mathematical learning resources on the internet required the existence of a file or a map, which contained information related to mathematical learning resources that are available in the internet. Mapping learning designs also required the existence of a file or a map, which contained information related to learning designs for the teaching and learning experiences. To work effectively, these electronic maps required software that acts as an associate reader to ensure that the data and information in the e-Maps is displayed in orderly manner and so that mathematics teachers can read and work with the map.

As illustrated in Figure 4.11, the tools are based on the concept that there are two components: 1) an e-Map, the electronic file that serves as a map and contains the data and information related to the mathematical learning resources or learning designs. A blank e-Map provided by researcher acts as a template to be filled with resources or information by teachers so as to create their own e-Map, and 2) a software associate reader, that can work properly with e-Maps to read the e-Map, load the contents of the e-Map.

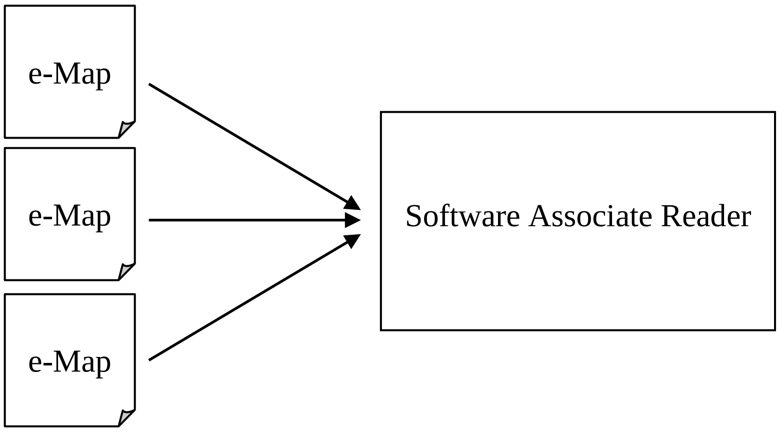
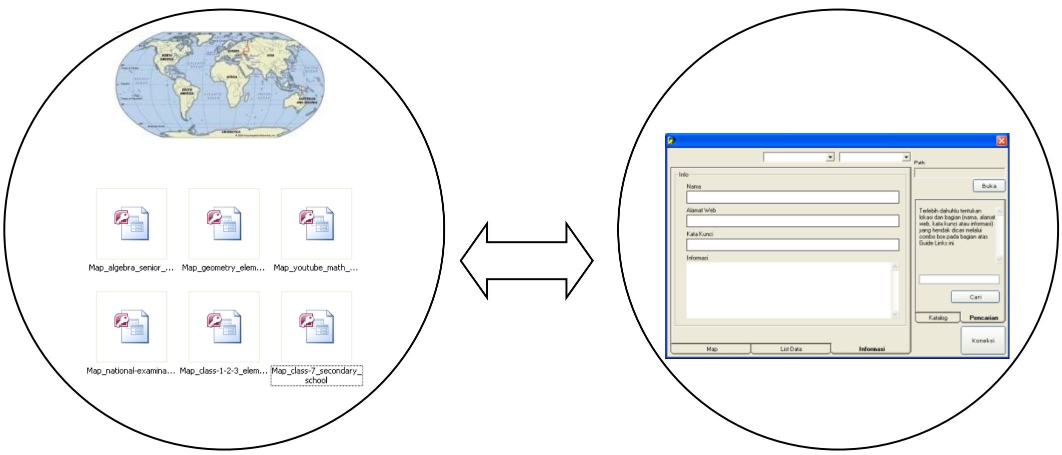


Figure 4.11 Electronic mapping tool concept

There are equivalencies between place address and web address for example, but there is no equivalence on the internet to the map or atlas of the earth. A map or atlas that presents the earth will useful in finding a specific location.

Table 4.28 Comparison between Earth and the Internet

Earth	The Internet
Place	Website
Place Address	Web address
Data and Information of place	Data and information of website
Map or Atlas	Currently Not Available



Electronic Maps

The Associate Reader of Electronic Maps

Figure 4.12 Concept of modifiable and shareable electronic maps

Electronic maps could provide an efficient cost effective, directional approach to mathematical learning resources in the internet by taking advantage of relevant hyperlinks in accord with the following suggestion

> *Of the uses of globally distributed hypertext and hypermedia technologies in education, it might be said that we live in the best of times and the worst of times. Over approximately two decades, we have seen hypermedia technologies (i.e., hyperlinks between nodes of digitally encoded information such as text, images, video, simulations, animations, and so on) advance from obscure military and basic research projects on specialized computers to form the basis of a globally distributed networked hypermedia environment known as the World Wide Web. In addition, commonly available and inexpensive multimedia handheld devices, laptop, and desktop computers allow students and teachers to connect to this global hypermedia environment using wired and, increasingly, wireless networks, thus providing countless opportunities for access to educational hypermedia and information resources.*
>
> (Jacobson and Avezedo, 2007, p. 1)

4.2.1.4 Developer tools

Both tools the e-Map and the reader, were developed on a Windows based platform. The electronic maps for mathematical learning resources on the internet are based on the Microsoft Access Database file that provides a template of the map. While this tool has been created in a commercial version of Microsoft Access, the modification of this template can be accomplished using available freeware or an open source version of Access database viewer applications, such as Open Office. For the electronic maps of learning designs, the map was based on 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. Visual Basic was used to develop the windows-based application to read the map.

The template for an e-map can be filled with resources by teachers, while the visual basic application acts as a software associate reader of this map. The associate reader reads the selected file and displays it according to the teachers' choice of view from the website data as supplied in the map. The map is based on geographic location of the world to make it more memorable than a URL when browsing the resource and also allows emphasis on the balance of resources between geographic areas. Teachers can also use a catalogue and a search function provided in the application (associate reader) while working with the map. If they find an interesting website of mathematical learning resources that is needed while using the associate reader, they only need to click a button in the application to visit this website, no typing a long web address or using a search engine to visit it.

4.2.2 Software Design

The electronic mapping system is the proposed solution to the problems of teachers' need for access to mathematical learning resources on the internet and to facilitate the sharing of learning designs. As represented in Table 4.28, the electronic map of internet learning resources is called a Geography-Based Resources Map (GRMap). This name is derived from its function of locating the resources on the internet based on its geographical location, for example by country or province. The name also positions this map as an atlas of the internet. The electronic map of learning designs, this map is called a Learning Design Map (LDMap). This name is also derived from its function of recording learning design information.

Table 4.29 Proposed mapping system

Type of Tool	Mathematical Learning Resources	Learning Designs
Electronic Map	*Name of tool*: Geography-Based Resources Map (GRMap)	*Name of tool*: Learning Design Map (LDMap)
	Function: To record information about mathematical learning resources in the internet, based on their geographical location (continent, and country)	*Function*: To record information about teacher's learning design, in particular the resources, tasks, process & support of each meeting.
Software Associate Reader	*Name of tool*: Guidelinks	*Name of tool*: LDSoft
	Function: To read the GRMap and guide teachers to select and locate mathematical learning resources in the internet. This software also has search and catalogue function.	*Function*: To read and modify the LDMap and enable teachers to read the learning designs data in appropriate view (Resources, Tasks, and Supports)

The template of GRMap is created by researcher and is filled with data of resources accessible via the internet, by teachers, allowing them to create their own versions of GRMaps that are then read by its associate reader. The associate reader of GRMap is called Guidelinks, because the creator provides links that will guide users accessing many mathematical learning resources in the internet as deemed appropriate by the creator. The links that will appear in the displayed map of Guidelinks is sourced from the GRMap that is connected to this reader. By browsing the displayed map or using catalogue and search function, a user can select one of provided resources than automatically connect to this resource by clicking the provided button as long as the computer is connected to the internet.

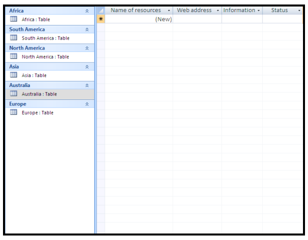
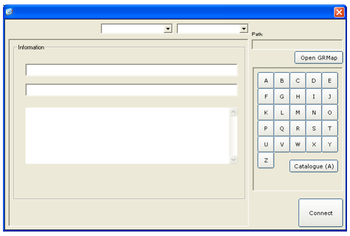
For learning designs, the template of LDMap is created by researcher and is to be filled with data of learning design, by teachers, allowing them to document and share their learning designs that are then read by its associate reader. The associate reader of LDMap is called LDSoft, because this reader will display the learning designs contained in an LDMap connected to this reader in an appropriate view (Resources, Tasks, and Supports). The tool is expected to document the expected "situation "of mathematics teaching and learning relevant to the term as following

> *Situation refers to an ensemble of problem-solving tasks and task environments designed to evoke a particular form of a didactical adaptation on the part of students, intended to help them construct some specific new knowledge (Ruthven, Laborde, Leach, and Tiberghien, 2009, p. 329)*

The software involved production of four layouts: 1) the Geography-based Resource Map, 2) the Associate Reader of GRMap, 3) the Learning Design Map (LDMap), and 4) the Associate Reader of LDMap.

4.2.2.1 Geography-based Resource Map (GRMap)

Table 4.30 Overview of GRMap and Guidelinks and process of use

Name	GRMap	Guidelinks
Type of application	Access file to enter resources to be read by Guidelinks	Windows-based application
Function	Template for teachers to fill with resources. This electronic map can be saved and reopened for addition resources to be added.	Provides multiple views of data eg geographical. Users can read, search, links through button to the internet resources.
Image of layout	 See Figure 4.13	 See Figure 4.14
File Name	GRMap_National-Examination.MDB	
Created by	Researcher	Researcher
Application written in	Microsoft Access	Visual Basic
Modification Notes	Structure and contents are modifiable by teacher. Microsoft Access or other database software is needed to modify structure.	Modifiable of structure by teacher. Modification of structure must correspond to structure changes in GRMap This requires Visual Basic software and programming skills
Template completed by	Teacher	
Support for modification	Related documentation located in the application package	Related documentation located in the application package

Gonzales and Sherer, (2004, p. 4) stated that geography is defined as anything that can be mapped. In this thesis, resources are mapped based on their location. At this time, popular educational resources available and accessible via the internet are mostly from countries with well developed technology, such as United States or Europe. The approach using geography-based map may encourage use of mathematical learning resources from developing countries that usually do not appear at the top level of search engine search results and as such they remain inaccessible by teachers in developing countries.

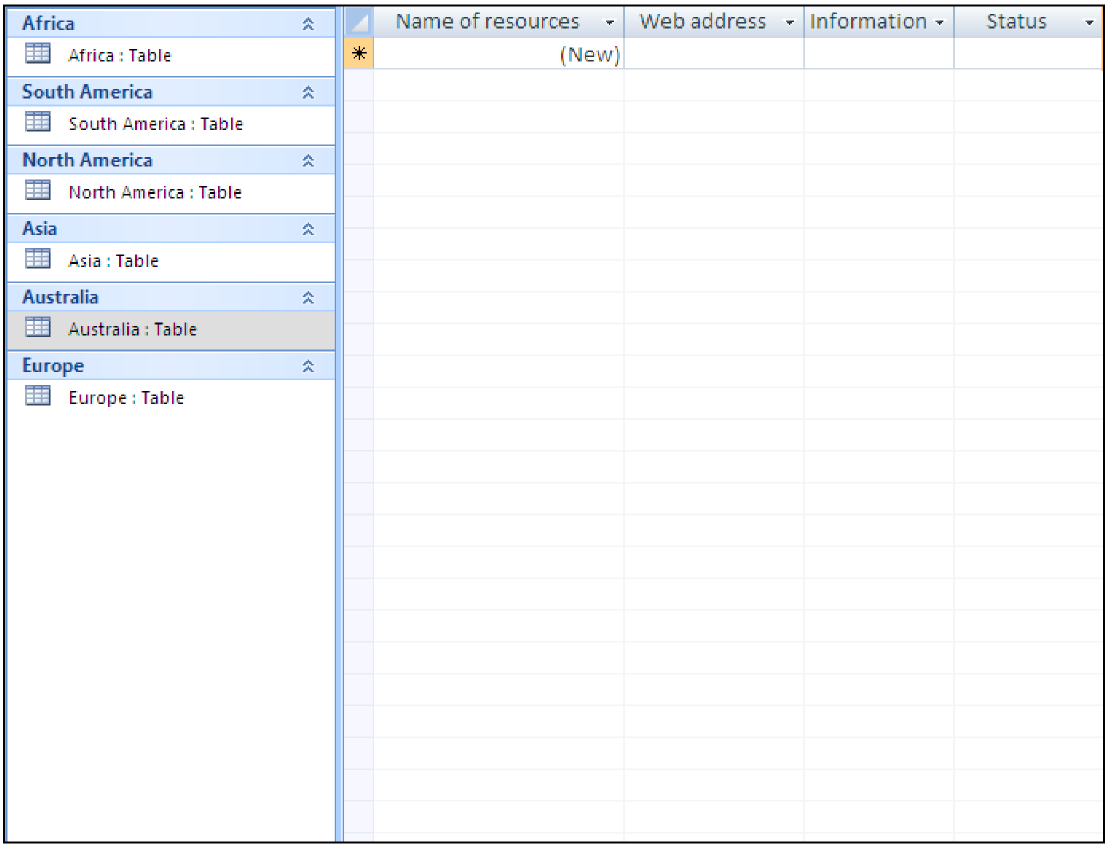


Figure 4.13. Layout of GRMap

The map itself is a basic tool of geography. Maps provide an enormous amount and variety of information, and help the reader locate places around the world (Gonzales and Sherer, 2004, p. 31). This basic concept of the maps is retained in the development of Geography-based Resources Map (GRMap) as the basic tool for mapping mathematical learning resources accessible from all over the world, records information related to these resources, and helps users to easily locate or visit the

resources using their own internet-enable computers or devices. The GRMap is intended to be modifiable and shareable to enable the sharing of knowledge contained in the maps between mathematics teachers, the intended users.

The layout of GRMap template indicates the links to resources according to location of continents of the world, Africa, South America, North America, Asia, Australia, and Euro. Based on these location categories, teachers engaged in the trials mapped and used resources.

For the data of resources, the following information of resources will be recorded

1) Name
   Assigned name of the resources available to be accessed via internet
2) Web address
   Web address of the resources available to be accessed via internet
3) Information
   Information related to the resources or comments from teachers about it, for example "a complete explanation about statistical analysis"
4) Status
   Teachers can manually add a description of the recent accessibility of the resources, for example, "inaccessible since August 2012". This information then is available for others sharing the map.

There is a limitation of 64 characters to be input to the fields, a restriction due to the limitation of current version of access file used as a template. In some cases this means the full web address cannot be displayed properly, however the solution to this problem involves use of a web service, such as http://www.bitly.com, to shorten the URL so the number of characters in the web address can be reduced not more than 64 characters, without make the function of hyperlink lost.

4.2.2.2 Guidelinks (the Associate Reader of GRMap)

For easy access by teachers the main window in Guidelinks shows the contents of the Geography-based Resources map, GRMap (refer Figure 4.14). Teachers also can view the list of data, and related information of resources applicable when they wish to use the eMap to visit resources (for an example, see the section "scenario of use" 4.2.2.5)

To facilitate browsing the resources, tools for search and catalogue functions are provided. With *Catalogue*, teachers can show sorted resources based on alphabetical name, for example resources with name started with letter "A", "B" or "C". With *Search*, teachers can search the specific name of resources provided in the selected GRMap. In general it can be said that teachers can use these tools to find appropriate resources available in the selected GRMap

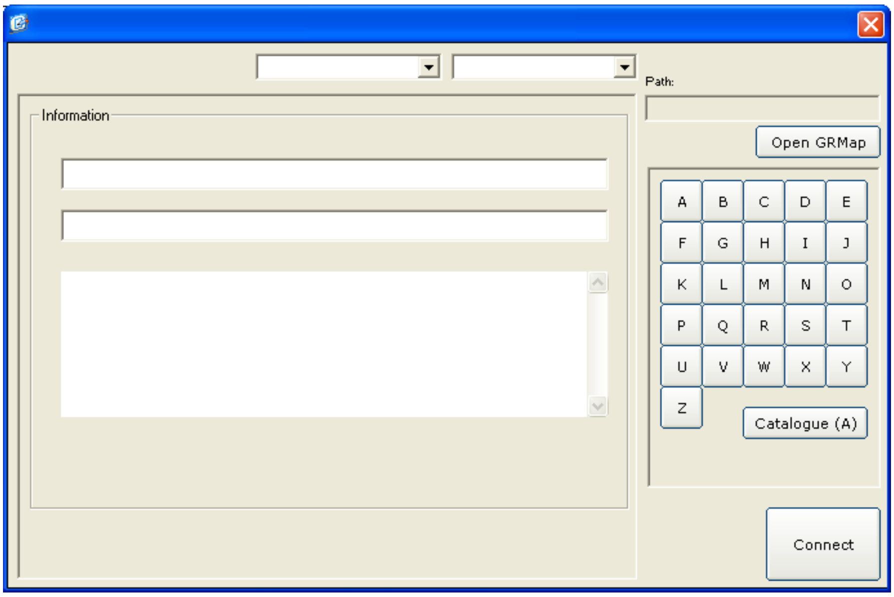
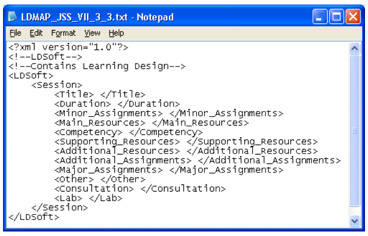
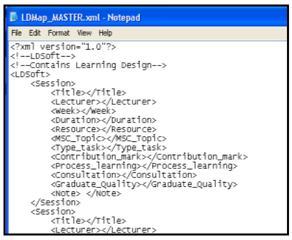


Figure 4.14 Layout of Guidelinks

4.2.2.3 Learning Design Map (LDMap)

Table 4.31 Overview of LDMap and LDSoft and process for use

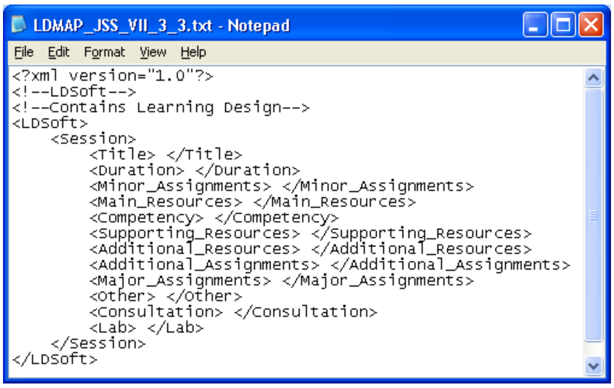
Name	LDMap template	LDMap	LDSoft
Type of application	Blank version of LDMap	XML file to be read and displayed by LDSoft Teachers do input data using LDSoft to the XML file	Associate reader to read and display LDMap
Image of layout	 See figure 4.15	 See Figure 4.16	 See Figure 4.17
Created by	Researcher	Researcher	Researcher
Application written in	XML	XML	Visual Basic
Modification Notes	To be filled with learning designs data using LDSoft	Content is modifiable by teacher but teachers do not enter content in the XML file. Modification to structure by changes to the XML code via a Text editor and must be accompanied by changes to LDSoft	Content is added and edited. Structure modifiable by teacher. Modification requires Visual Basic software and must align with changes to the XML file
Template completed by	Teacher	Teacher	Teacher
Support for modification	Related documentation located in the application package	Related documentation located in the application package	Related documentation located in the application package

*Note by the completion of the later phases of the project, two additional tools LDForm (an excel-based version of LDSoft to create LDMap) and Learning Design-based Curriculum Reviewer (Section 5.4) designed and developed to improve the usability of these tools for use in curriculum review. LDForm only enables the conversion of learning design data contained in the excel file to LDMap (this tool is unable to read and modify the LDMap), while the LDSoft is able to read and modify the existing LDMaps

An XML file defines the structure of the LDMap, and the learning design data is input by teachers using LDSoft, the associate reader, into LDMap. The Associate

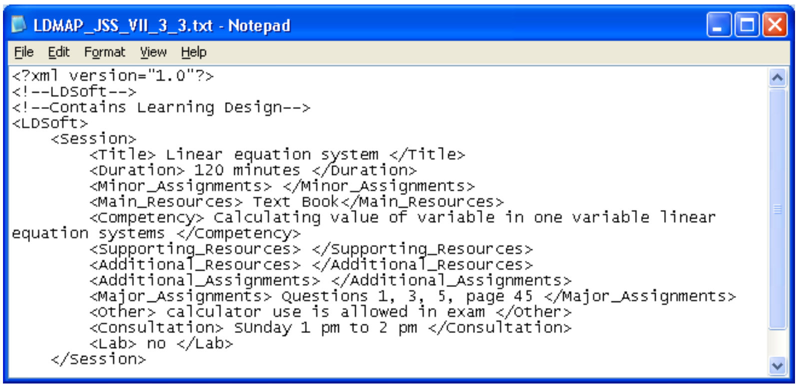
reader will also display the data and provides functionality in terms of gathering data for Resources, Tasks, and Supports. The associate reader, LDSoft is written in the Visual Basic programming language. The LDMap template is presented in Figure 4.15. Using LDSoft the template the researcher produced, is filled by teachers with learning design data to have it read and displayed in a variety of formats.

In LDMap, each component (title, lecturer, ..., lab) of the learning design is listed. The standard list included in the LDMap template is provided as illustrated in Figure 4.15 by the researchers, and the map can be filled by the data through its nodes. For example part of nodes filled is displayed in Figure 4.16. Teachers do not need to view this XML code unless they wish to modify the fields displayed in the reader. In its current form it will be displayed and works properly with the associate reader. Schools or teachers can modify this list to satisfy their need for different information to be included. However the modification of this list (components of learning design) has to be consistent with modifications to the associate reader. If the list is changed in the LDMap, the associate reader also needs to be reconfigured. Documentation supplied with the files documents how teachers can modify the XML code and the associated LDSoft, the reader.




```
<?xml version="1.0"?>
<!--LDSoft-->
<!--Contains Learning Design-->
<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 4.15 Layout of LDMap (template)




```
<?xml version="1.0"?>
<!--LDSoft-->
<!--Contains Learning Design-->
<LDSoft>
    <Session>
        <Title> Linear equation system </Title>
        <Duration> 120 minutes </Duration>
        <Minor_Assignments> </Minor_Assignments>
        <Main_Resources> Text Book</Main_Resources>
        <Competency> Calculating value of variable in one variable linear
equation systems </Competency>
        <Supporting_Resources> </Supporting_Resources>
        <Additional_Resources> </Additional_Resources>
        <Additional_Assignments> </Additional_Assignments>
        <Major_Assignments> Questions 1, 3, 5, page 45 </Major_Assignments>
        <Other> calculator use is allowed in exam </Other>
        <Consultation> Sunday 1 pm to 2 pm </Consultation>
        <Lab> no </Lab>
    </Session>
```

Figure 4.16 Layout of LDMap (filled)

4.2.2.4 LDSoft (the Associate Reader of LDMap)

When LDSoft is opened, it looks like Figure 4.17. It is ready for data entry to open blank template or existing LDMap using LoadLD button. After that this is then ready for data to be supplied to it by the teacher. When LDSoft is used to open an existing LDMap it shows the mapped learning design in the provided form as illustrated in the Figure 4.16 drawing data from existing LDMap and displaying the learning design in LDSoft. The LDSoft can also create a new LDMap, with the teacher modifying the contents of the currently opened LDMap in LDSoft and saving it to a new file name (map)

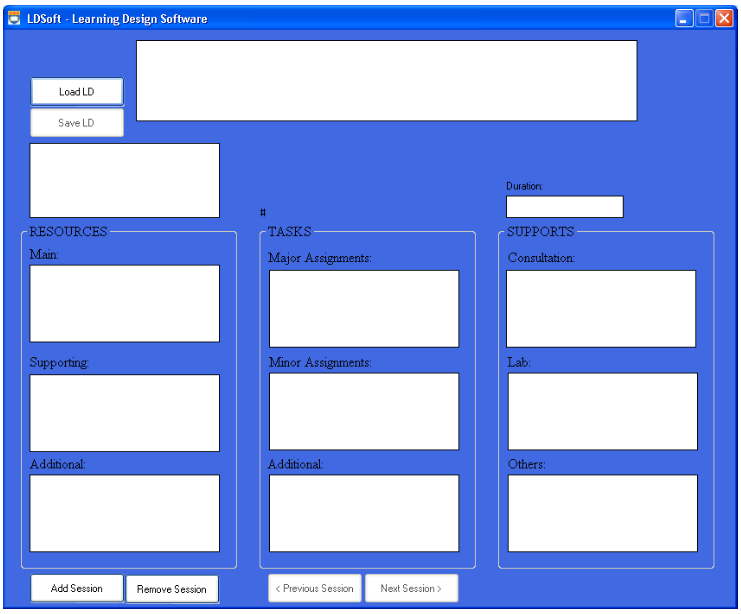


Figure 4.17 Layout of LDSoft

The LDMap providing details of the learning design for the subject through LDSoft is complemented by the production of a map of resources, by a variety of names for example but ideally ,what is the sort of name and extension – is it a variant of LDMap used by the teacher in the teaching of this subject.

4.2.2.5 Scenario of use

A scenario is a sequence of events that occur in a particular execution of the system (Jalote, 2006, p. 343). Scenarios of use of the electronic mapping system are similar. There are two electronic mapping tools, called Geography-Based Resources Map (GRMap) and Learning Designs Map (LDMap), together with each associate reader, called Guidelinks and LDSoft. The maps are electronic files ideally named of the form of GRMap_name of topic (for GRMap) or LDMap_name of course (for LDMap) for easy identification, containing data in the form of information about geography-based resources created by the GRMap tool or learning design data from the LDMap tool. Information contained in this map files can be displayed appropriately using each associate reader.

Teachers, or users in general, start by using a blank template in either the GRMap or LDMap tools. They also allow users to modify the contents and share the existing eMap of GRMap or LDMap. The teacher, starts using the electronic mapping system by supplying information about the resources or learning design of the subject to either GRMap or LDMap. Opening the associate reader then connects the associate reader to the appropriate electronic map file (GRMap or LDMap) to be displayed and manipulated in the associate reader. After the associate reader is connected to the electronic maps (GRMap in mathematical learning resources, or LDMap in learning designs) then the teacher can start working with the maps using the associate reader, whether exploring resources on the internet or in the case of learning design use by reading and identifying how a subject has been taught. Both for GRMap and LDMap, teachers are allowed to modify and share the existing electronic map files created by other teachers.

For both the GRMap tool and the reader Guidelinks, users are provided with catalogue and search functions, as the use of electronic mapping system deals with data and possibly many sources of data in the form of resources in the internet. Having searched and found in the mapped resources the user can visit the selected resources by clicking button provided in the Guidelinks. No creating new electronic map is available because the GRMap functions is just to work with the existing GRMap.

For the LDMap tool and the reader LDSoft, the user is provided with the capability of creating a new LDMap file or modifying an existing LDMap file. This capability enables them to create their own LDMap or e-map for use in teaching aligned to curriculum or to create the e-maps for teaching that are not aligned to any curriculum, or for personal purpose.

Figure 4.18 illustrates the detailed process of this use for GRMap and the associated Guidelinks, and Figure 4.19 for LDMap and its associated reader LDSoft.

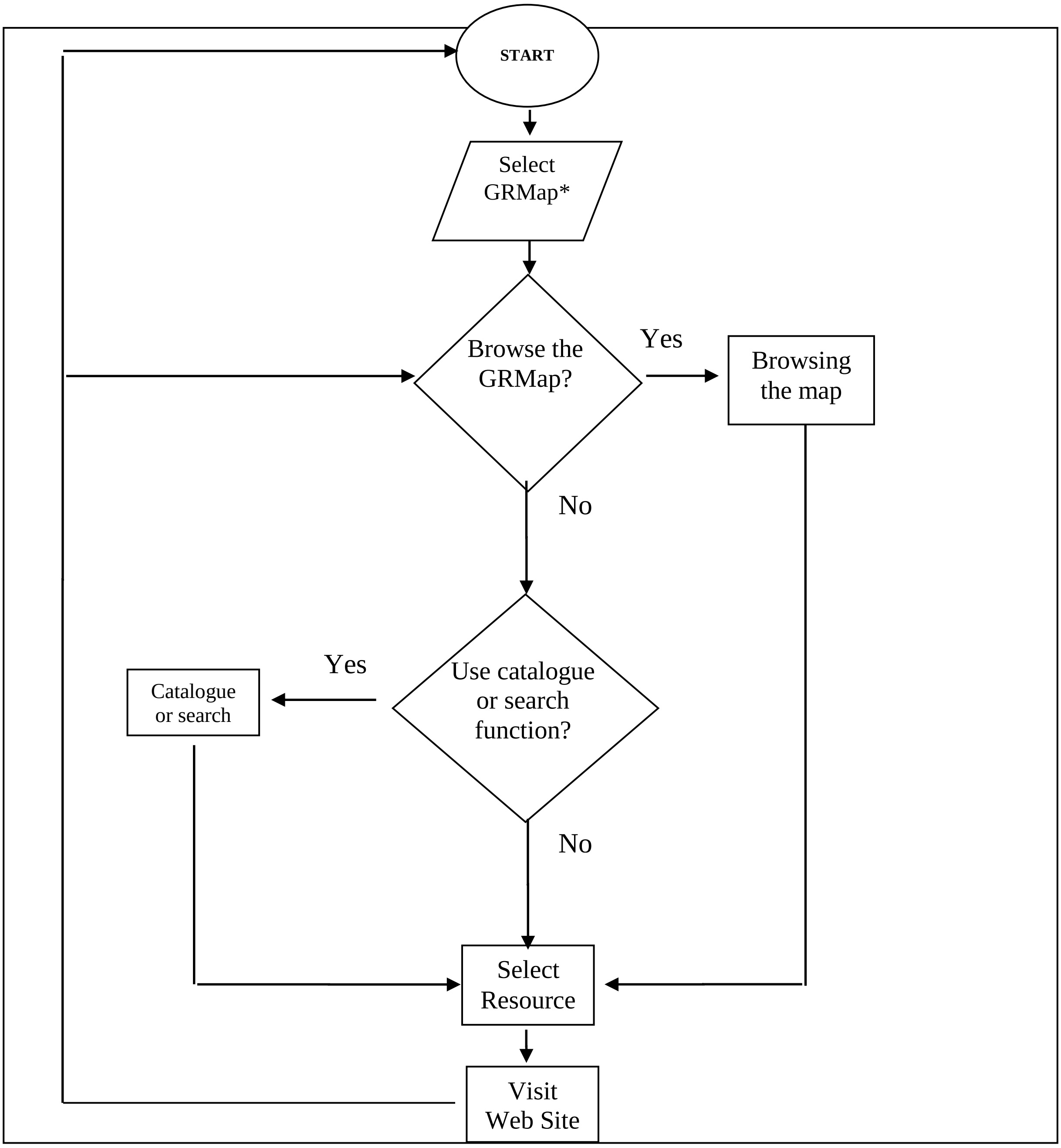


Figure 4.18 Scenario of use of GRMap and its Associate Reader

*Note: the first GRMap is provided by researcher. Teachers can modify the GRMap to create their own version of GRMap, retaining the same fields/nodes of information, but varying the contents. The modification of the structure and field of information collected in GRMap requires MS Access of other Database editor.

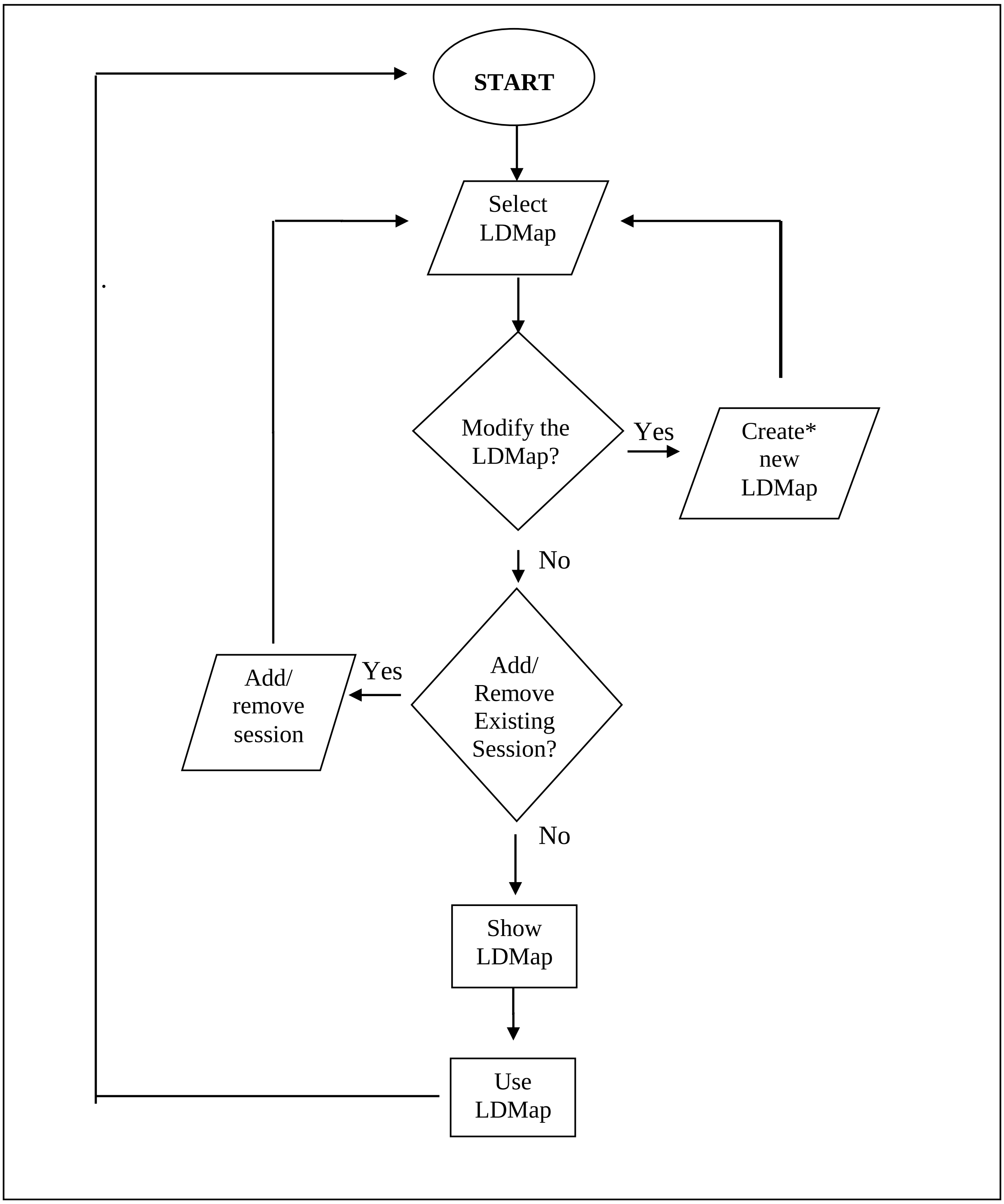


Figure 4.19 Scenario of Use of LDMap and Its Associate Reader

*Note: in fact teachers modify the blank LDMap template (provided by researcher), not create a new LDMap

For Guidelinks, as illustrated in Figure 4.18, after starting Guidelinks, the user will need to select one of the available GRMaps. After that they can browse the map geographically, for example based on the geographical continents where the resources are located or to use a catalogue and search function to select one of the resources, then they can visit the resource by clicking the button.

For the associate reader LDSoft, as illustrated in Figure 4.19, after starting the LDSoft, the user needs to select one of the available LDMaps, including the possibility of a blank template, to work with. After that they will have an option to create a new LDMap or to save modifications to an existing one. Alternatively a user can use the associate reader just to display or use a LDMap, without the specific purpose of modifying or creating a new one. Displaying and perhaps modifying LDMaps is useful when a user need to know how other teachers have taught a given subject. They may wish to personalise the subject in some way and therefore wish to modify the map. They can learn from it, or modify the existing learning design to fit their teaching style. Alternatively when a user would like to create a map of the design of learning given some curriculum, or would like to teach something differently, they can create a new LDMap. The creation of this LDMap will be become the documentation for what they think should be done or happen in the learning process, so that other teachers can follow or learn from the user about how the user taught this subject.

4.2.3 Coding

To create and modify GRMaps and LDMaps no coding is required as to undertake these functions simply requires basic computer skills such as writing, copying and pasting text as information is supplied to the various fields to GRMap or LDMap. Coding is only required to further develop the associate readers of these maps, that is to extend their function, to say collect another set of information, so users will need to code only when they want to improve or modify the associate readers. Following is the explanation of coding used in the development of the associate readers (Guidelinks and LDSoft).

Guidelinks may be considered to be an application rather than an ordinary file, and as such the development of this application is requires coding. As the developer tool is Microsoft Visual Basic, much of the application can be visually designed avoiding some complexity of coding.

Coding of Guidelinks, as illustrated in Figure 4.20 is required for the *Open GRMap* button, the *catalogue* and *search* functions.

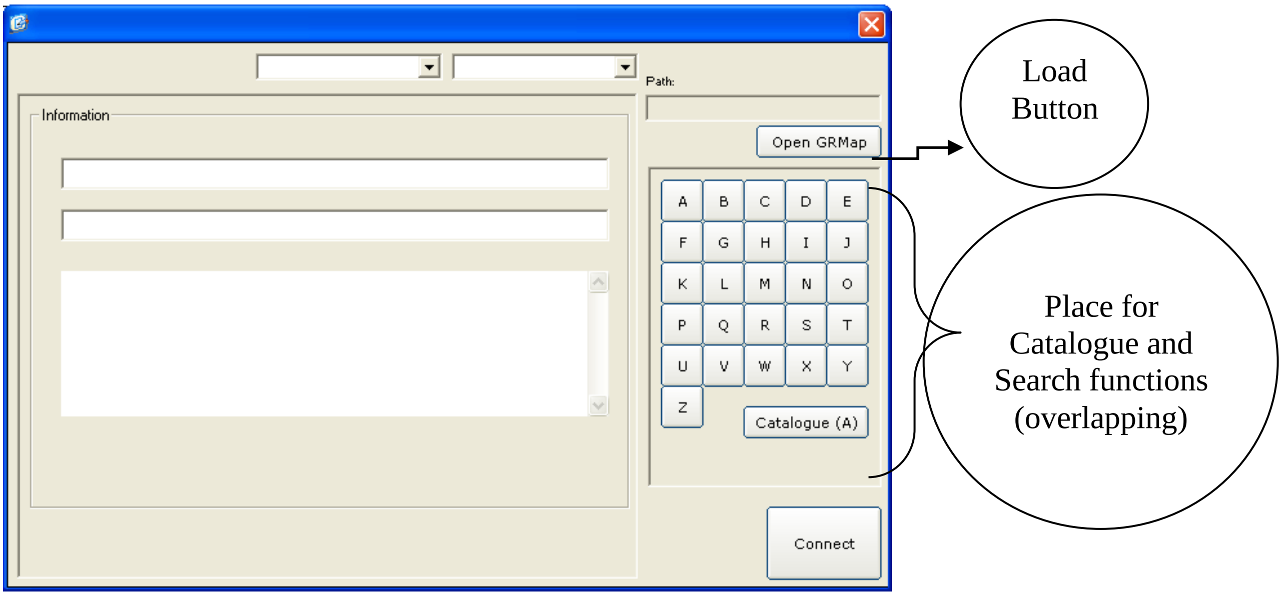


Figure 4.20. Guidelinks main form

The code to create these functions written in the visual basic programming language is provided in Table 4.32

Table 4.32 Partial list of code for load button and catalogue function

Load Button:
To load GRMap and connect the associate reader to the selected map

```
Private Sub cmd1_Click()
combo1.Clear
combo2.Clear
DBGrid1.Visible = False
comdialog1.DialogTitle = "Browse Guidelinks"
comdialog1.Filter = "GRMap|*.mdb"
comdialog1.CancelError = True
On Error GoTo errorhandler
comdialog1.ShowOpen
  txt1.Text = comdialog1.FileName
  DoEvents
  cmd2_Click
  DBGrid1.Visible = False
Exit Sub

errorhandler:
  Exit Sub

End Sub
```

Catalogue Functions:
To work with data supplied by GRMap by cataloguing the required data if needed by users

```
Private Sub cmd3_Click(Index As Integer)
txt3.Text = cmd3((Index - 1) + 1).Caption
If cmd3((Index - 1) + 1).Caption = "A" Then
cmd4.Caption = "Katalog" & cmd3((Index - 1) + 1).Caption
End If
cmd3.Caption = "Katalog " & cmd3((Index - 1) + 1).Caption
On Error Resume Next

End Sub
```

LDSoft is also an application that requires come coding. The development of this electronic mapping system also involved Microsoft Visual Basic code.

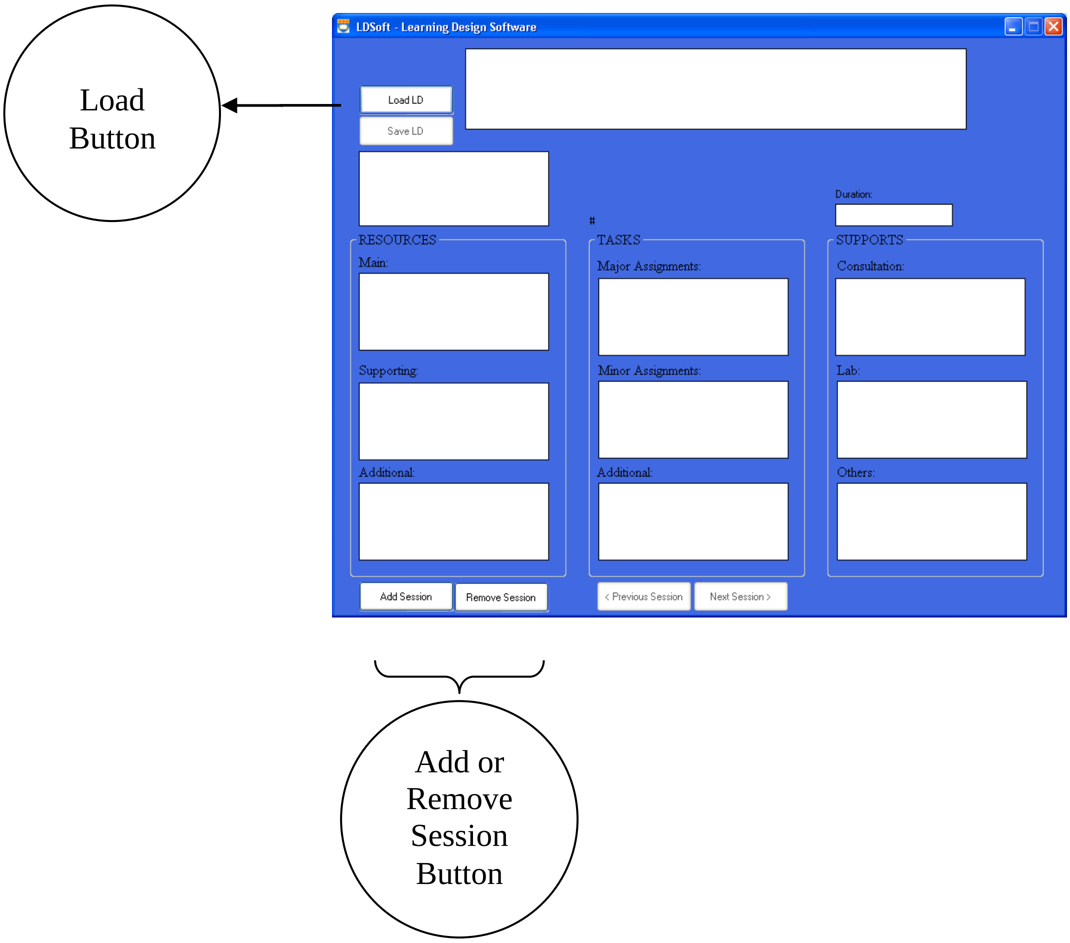


Figure 4.21. Coding of LDSoft (main code)

Coding for two main parts of the LDSoft, the button to load the learning design (LD) and to add or remove learning design (LD) is explained in Tables 4.33.

Table 4.33 List of code for load button and add/remove session

Load Button To load LDMap and connect the associate reader to the selected map

Private Sub butLoad_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles butLoad.Click
Dim pStrLDFile As String = getFile()
If (pStrLDFile <> "<NULL>") Then
If (loadLDFile(pStrLDFile)) Then
MessageBox.Show("The LD File is Ready for Use")
If (cColSessions.Count > 0) Then
Call displayCurrentSession(True)
butSave.Enabled = True, butPrev.Enabled = True, butNext.Enabled = True
Else
butSave.Enabled = False, butPrev.Enabled = False, butNext.Enabled = False
End If
Else
MessageBox.Show("The LD File is Damaged")
End If
End If
End Sub

Add/Remove Session Button To add existing learning design sessions available in the working Learning Design Map

To Add
 	
Private Sub butAdd_Click Handles butAdd.Click
Dim pFrmAddsession As New frmaddsession()
If (pFrmAddsession.ShowDialog = DialogResult.OK) Then
Call cColSessions.Add(pFrmAddsession.session)
cIntCurSession = cColSessions.Count
Call displayCurrentSession(False)
butSave.Enabled = True
butPrev.Enabled = True
butNext.Enabled = True
End If
End Sub
 	
To Remove
 	
Private Sub butRemove_Click Handles butRemove.Click
If (cColSessions.Count > 0) Then
If (MessageBox.Show("Remove the current session?", "Remove", MessageBoxButtons.YesNo, MessageBoxIcon.Question) = DialogResult.Yes) Then
Call cColSessions.Remove(cIntCurSession)
If (cIntCurSession > cColSessions.Count) Then
cIntCurSession -= 1
End If
Call displayCurrentSession(False)
End If
End If
End Sub

4.2.4 Testing

The electronic mapping system was tested in Windows XP and Windows 7, the version of Windows that are widely used in developing countries (see chapter 3, section 3.2.1.1). Two unexpected problems occurred during testing of the installation, with respect to “use“ and “uninstall” of the associate readers Guidelinks and LDSoft, these problems and solutions have been documented in Table 4.34. Documentation provided for users also provides this list of the possible problems and how solve these problems. After this testing, the electronic mapping system was ready for use by other people on site, in particular by mathematics teachers in developing countries.

Table 4.34 Known problems and its solutions

Guidelinks Windows XP & Windows 7	**LDSoft** Windows XP and Windows 7
Installation	
Problem: Incomplete installation.	Problem: System .Net Framework is Required
Explanation: This problem happens because several files cannot be copied to the user computers.	Explanation: This problem happens because the user computer is not up to date because did not have component .Net installed
Solution: Only accident in a rare case. It would happened because the installation file is not complete (corrupted)	Solution: User need to install the .Net Framework. Available in Microsoft update ((http://www.microsoft.com/en-au/download/default.aspx), and also available from researcher
Use	
Problem: Active X component (OCX) is not registered.	No problem is found.
Explanation: This problem happens because the ActiveX component used by the application is not available in the user’s computer.	
Solution: File Regedit, to automatically edit user registry and register the ActiveX component supplied to the installer	
Uninstall	
No problems found.	No problems found.

The implementation of the electronic mapping system and onsite testing was conducted through case studies of 13 mathematics teachers in Bojonegara Sub District, Indonesia.

4.3 Phase III: Implementation

Following approval by the UOW ethics committee, an official letter was sent to the Head of Bojonegara Education Office requesting permission to conduct collaborative research in Bojonegara Sub District. A similar letter was also prepared for the Head of each school that was to be visited.

According to discussions with one of the senior head-masters in Bojonegara Sub District, Indonesia, the best time to visit schools was considered to be the end of January, with interviews, discussions and collaboration indicating that the research activity should not go past May, because the National Examinations are held by the government, in June and July. Teachers and schools need to make a preparation for the National Examination in May. The Headmaster also suggested that the visitation to each teacher or face-to-face meeting should be short, so that it would not disturb the teachers' daily activities. It was also suggested that the visitations start with the teachers of elementary schools and then continue to teachers of Junior Secondary Schools, and finally to teachers of Senior Secondary Schools.

4.3.1 Visitation

The first visitation to a school was on Tuesday, 24 January 2012. Three elementary schools were visited. In this first visitation, the researcher invited teachers from each school to participate in the research. Sometimes the researcher visited a group of teachers, at another times individual teachers, depending on the teachers' time and availability. Through this visit, if possible and allowed by head of school, the researcher introduced the teachers to the mapping system.

Through this first visitation, the researcher scheduled further visits to the teachers on 26 January 2012, 30 January 2012 and 2 February 2012. Each teacher was visited three or four times dependent upon their and the researcher's need. The regular activities undertaken in these visits included: 1) Explanation as to the purpose of the research (refer Figure 4.22); 2) Discussions, regarding the ideas behind and implementation of the mathematical learning resources and learning design electronic mapping systems (refer Figure 4.23); 3) Support of the teachers use and evaluation of the electronic mapping systems; and 4) When allowed by teachers, photos and videos recording of teachers' activities.

Figure 4.22 Introducing the electronic mapping system to a group of teachers

Figure 4.23 Introducing the electronic mapping system to a teacher

After completing the visitation to mathematics teachers from elementary schools, the researcher proceeded to undertake the same visits and data gathering at the junior secondary schools and then the senior secondary schools. The process in the junior secondary schools and senior secondary schools was generally the same as the process conducted in the elementary schools. The summary of visits is reported in Table 4.35

Table 4.35 Date of Visitation to Mathematics Teachers

No	Mathematics Teacher	School Level	Date of Visitation (year 2012)				Duration of Working Together
			First	Second	Third	Fourth	
1	Teacher 1	Elementary School	24 Jan	26 Jan	20 Feb	-	27 days
2	Teacher 2		24 Jan	26 Jan	20 Feb	-	27 days
3	Teacher 3		24 Jan	30 Jan	16 Feb	20 Feb	27 days
4	Teacher 4		24 Jan	30 Jan	16 Feb	20 Feb	27 days
5	Teacher 5		26 Jan	10 Feb	11 Feb	24 Feb	29 days
6	Teacher 6		26 Jan	10 Feb	11 Feb	24 Feb	29 days
7	Teacher 7	Junior Secondary School	14 Feb	15 Feb	20 Feb	-	7 days
8	Teacher 8		14 Feb	15 Feb	20 Feb	-	7 days
9	Teacher 9		18 Feb	26 Feb	29 Feb	4 March	17 days
10	Teacher 10		18 Feb	26 Feb	29 Feb	4 March	17 days
11	Teacher 11	Senior Secondary School	7 March	13 March	20 March	-	14 days
12	Teacher 12		7 March	13 March	20 March	-	14 days
13	Teacher 13		10 March	31 March	-	-	22 days

4.3.2 A guide for teachers

All participating teachers were provided with the electronic mapping system software package and were asked to use and evaluate the software.. The researcher also provided the teacher with printed documentation regarding the software. Step by step use of the electronic maps was explained to teachers as follows:

1) A template for creating electronic maps has been designed by the researcher based on discussions with teachers. Using this template, teachers can create their own electronic maps of mathematical learning resources in the internet.

2) When the associate reader is installed on a computer, the reader can be used to connect to a number of electronic maps.

3) When an electronic map is selected, the map will be displayed in the associate reader allowing the map to be browsed and viewed as a list of data.

4) If needed, for example when the map contains a large amount of information, the catalogue and searching functions can be used to explore the map.

5) Key words and information related to the selected web sites using the tab provided can be read.

6) The button provided is clicked to visit the selected web sites. This button can be use several times as long as the map is still in use.

The diagram of how the software can be use by teachers is provided in Figure 4.24

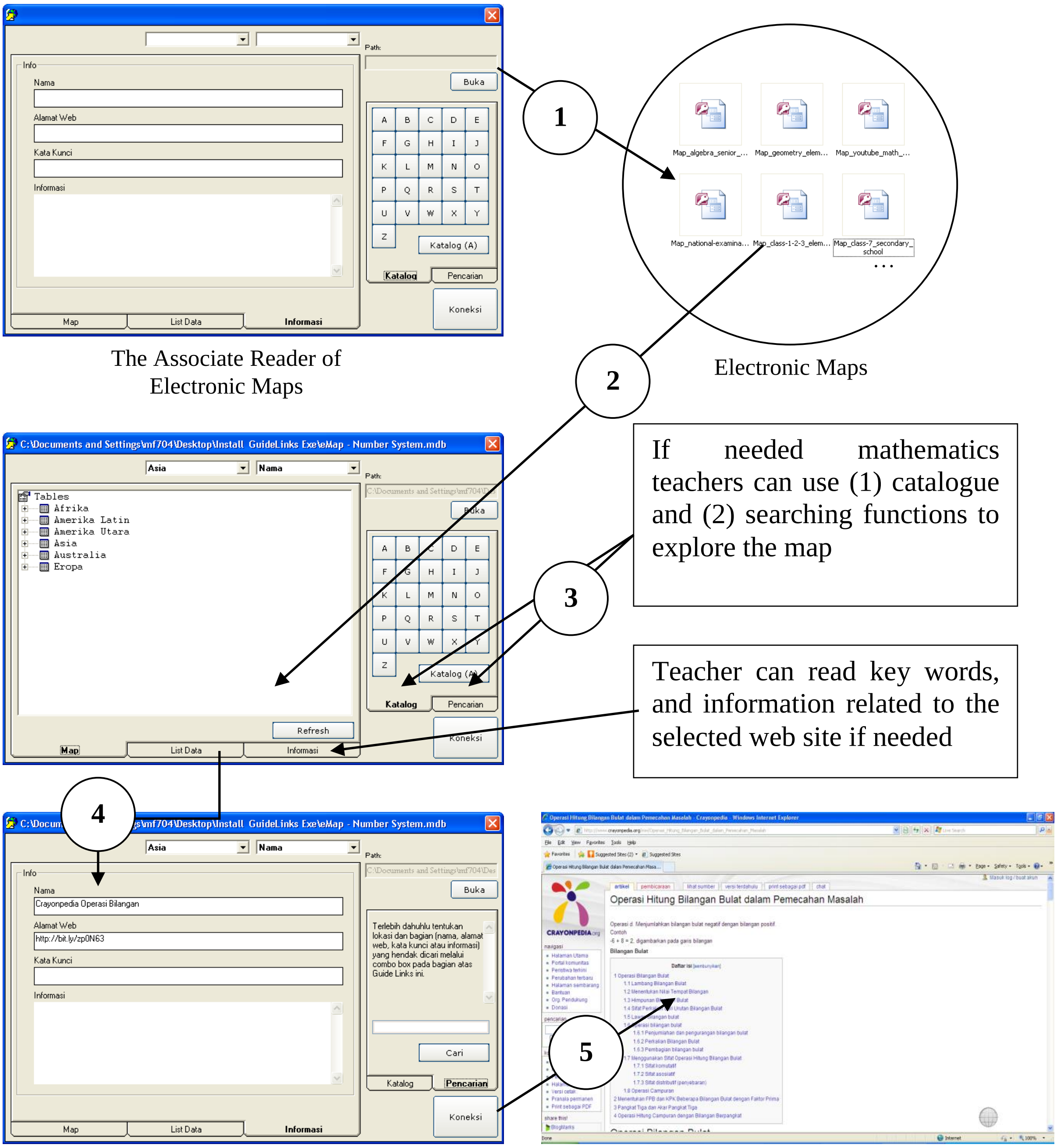


Figure 4.24 An example of the use of electronic mapping system

4.3.3 Demographics of participants

The trials were undertaken through thirteen case studies of mathematics teachers in Bojonegara Sub District, Indonesia. The discussions and interviews in this phase examined the usability of the tools as they were tested by the teachers and in so doing possible improvements and issues were identified.

The teachers were selected from a group of teachers who participated in the earlier localised investigations 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. In choosing the teachers for the case studies, the researcher 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.

Of the 13 participants in the research, three (23.1%) are male and 10 (76.9%) are female. Six participants were mathematics teachers at elementary schools, four teachers were mathematics teachers of junior secondary schools, and three teachers were mathematics teachers from senior secondary school. The details of participants in regard to gender are provided in Table 4.33

Table 4.36 Details of Participants

School level	Female		Male		Total
	N	%	n	%	n
Elementary School	5	83.3	1	16.7	6
Junior Secondary School	4	100	0	0.0	4
Senior Secondary School	1	33.3	2	66.7	3
Total	10	76.9	3	23.1	13

In term of the use of schools' computers, 11 participants (84.6%) used computers at schools, while two participants (15.4%) did not. As reported in Table 4.37 all school computers used were running with Windows Operating System, as expected by the choice of platform and the earlier needs analysis. All participants have and used computers externally to the schools, each with the windows operating system. According to the participants, eight computers were notebooks (61.5%) and six computers were desktop machines (38.5%).

Table 4.37 Computers used by participants

School level	Notebook PC		Desktop PC		Other		Total
	N	%	N	%	n	%	n
Owned by school	3	50.0	3	50.0	0	0.0	6
Owned by teacher	4	80.0	0	0.0	1	20.0	5
Total	7	63.6	3	27.3	1	9.1	11

The teachers who participated in the research were drawn from eight grade levels, as reported in Table 4.38.

Table 4.38 Grade levels of participating teachers

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

4.3.4 The use of the tools: case study of 13 mathematics teachers

The electronic mapping system of mathematical learning resources on the internet was used and tested by participants either at school or at home. The teachers used the electronic maps provided by researcher to discover resources. The resources visited by participants could be mathematical learning resources for references, or for use by them to teach their students. As revealed by Pierce and Ball (2009), teachers' perception may influence teachers' use of technology for teaching and learning. In the case of electronic mapping system, the case studies provide information of teachers' view about the use of these tools.

The case study of the 13 mathematics teachers' trialling the electronic mapping system provided insights as follows:

1) Teacher 1

Teacher 1 did not bring notebook to school, so she trialled to install and use both of the software at home. After tried the software she expressed her opinion as follows:

> *I am strongly agree that this system to be implemented in class or school, if teachers can own this [software] and facilities [computer, internet] available to use it (Teacher 1)*

2) Teacher 2

Teacher 2 attempted to map his learning designs using LDMap and was trialling installation of the software at school. He allowed the researcher to take photo documentation when he was trialling the software. There was a problem in installation at the first time, but the problem resolved on a second attempt. According to teacher 2:

> *The availability of electronic mapping system for mapping resources and learning designs will be benefit for students, teachers, and community, [in general] for formal and non-formal education (Teacher 2)*

3) Teacher 3

Teacher 3 did not bring her notebook to the school, however there was a computer available at her school for use by teachers. She filled in the questionnaire, but made no written or spoken comments regarding her experience on using the software.

4) Teacher 4

Similar to Teacher 1, Teacher 4 trialled to installed and used the software at home. She expressed the comment of the electronic mapping system as follows:

> *I strongly agree that this design and system of tools will be useful for teachers, students, schools, and education office for improvement and innovation [in teaching and learning/ education] in the future (Teacher 4)*

Teacher 4 expressed her concern about the burden of tasks such as preparing written teaching documents (syllabi, lesson plans), and was interested in knowing whether or not the LDMap could be useful for solving these problems. According to her, it may good that the Education Office asked teachers to create LDMap to replace the duty of writing syllabi and lesson plans. She also concerned that there could be a possible of misuse of the shareable LDMap in that some teachers may only copy other teachers works, and might not create any of their own LDMaps for teaching and learning.

Perhaps later modifications of the mapping tools could create an acknowledgment field/node.

5) Teacher 5

Teacher 5 is a mentor to other teachers, and sometimes officially visited other schools to teach or share educational lectures with teachers. She explained to the researcher that many learning resources are available in the internet, and that she sometimes downloaded them for use in class. She only provided a general statement that the software is good for teachers. Further discussion with her was

about converting written document of teaching and learning to digital document so it will be easier for teachers and reduce their work load.

6) Teacher 6

Teacher 6 is a vice headmistress of the school. She trialled the software using her netbook at school, thinking about creating GRMap for her subjects and after that she expressed the opinion of the system as follow:

> *[The optimisation] of [the use of available] learning resources in the internet and learning design is very good because teachers and students will find it easier to learn and access these resources using technology. It is also hopefully that teachers will be more professional [on teaching and learning with technology] (Teacher 6)*

7) Teacher 7

Teacher 7 allowed researcher to document how she taught mathematics and discussed how to document her way to teach mathematics. Unfortunately follow up did not result in a concrete learning design map. The teacher?researcher? felt that ease of use of the software and how teachers feel that this activity will benefit them is important in encouraging them to create and modify GRMap and LDMaps.

8) Teacher 8

Teacher 8 modified the GRMap template to include resources accessible via the internet to support her students for national examinations. In this case she modifies the map to be based on the national examination topics. She provided general comment that the electronic mapping system is good for teachers.

9) Teacher 9

Teachers 9 prepared a GRMap for the Geometry topic. She searched for resources in the internet and faced difficulty with the long hyperlink. At this case

researcher suggest to them to use web service, such as www.bitly.com to shorten the link.

> *More dissemination [of these tools] is needed, so many teachers will know [about these tools and its benefit] (Teacher 9)*

10) Teacher 10

Teacher 10 is a teacher in several schools and institution (such as a learning course centre). He provided comments regarding the tools as follows:

> *[I would like to create] good electronic maps, a comprehensive one, not a specific to a particular topic ... these maps should be able to support the teaching and learning process in the class, thus provide effective and efficiency for teachers and benefit for them. ... I agree that these electronic maps to be implemented in all school or region [of Bojonegara Sub District), to facilitate effective teaching and learning process (Teacher 10)*

11) Teacher 11

Teacher 11 was inspired by the concept of the learning designs being captured through the LDMap. He provided the following comment:

> *If the tool can be disseminated to teachers widely, to educators community it will be better. Educators may knowhow to continue the development and communicate these (tools) to their students better. I strongly agree with the idea [of the tools] (Teacher 11)*

12) Teacher 12

Teacher 12 indicated to the researcher that she was interested in the mapping tools but after completing the questionnaire (in the next meeting) she indicated to no longer participate in the research – no explanation was given.

13) Teacher 13

The main discussion with Teacher 13, after researcher demonstrated the electronic mapping system was about the future of electronic mapping system. She discussed the distribution of the tools to other teachers and suggested it may good for them. She advised that:

> *Need more dissemination to schools [and teachers]*
> *(Teacher 13)*

She strongly supported the implementation for use by many teachers, not only for selected teachers. Many teachers may take advantage of the tools.

Teachers were expected to use the electronic maps and to circulate the maps to other teachers (participating and non participating mathematics teachers). The circulation could be inspired through personal relationships between teachers (in or across the schools) or teachers' engagement in groups. There were six pairs of teachers, where each member of the pair was in the same school. They could also recommend and share the maps with other teachers or their students so these people are would be also to visit these resources. It was expected that the participating teachers would share the electronic maps and tools with other mathematics teachers in their school, although these additional teachers were not interviewed as part of this research. Teachers were also expected to share across the levels of school due to their family relationships.

As illustrated in Figure 4.25, several links between teachers were evident, these links were the ways the shared of GRMap and LDMap among teachers (participating and non participating in the activity). Observations confirmed the expected circulation made possible due to their common daily activities, engagements, and communications between these pairs of teachers. Beside the interactions of these pairs, some of teachers were observed to have relationships with teachers from other schools. The Elementary School 1 of Teachers 1 and 2 is near to the Elementary

School 2 of Teachers 3 and 4. It was observed that the relationship between these schools is very good. Teachers sometimes visited their counterpart school. It was also observed that the Teacher 4 sometimes visited the school of Teacher 5 and 6. Teacher 4 due to her position as financial coordinator for School Operational Funding from Indonesian Government frequently visited the central Elementary School 3 of Teacher 5 and 6 in Bojonegara Sub District. Teacher 6 also frequently visited other schools due to her position as trainer for other teachers (including mathematics teachers). Teacher 6 and Teacher 8 have a family relationship, while Teacher 8 and Teacher 9 knew each other. There were no observed links for Teacher 13.

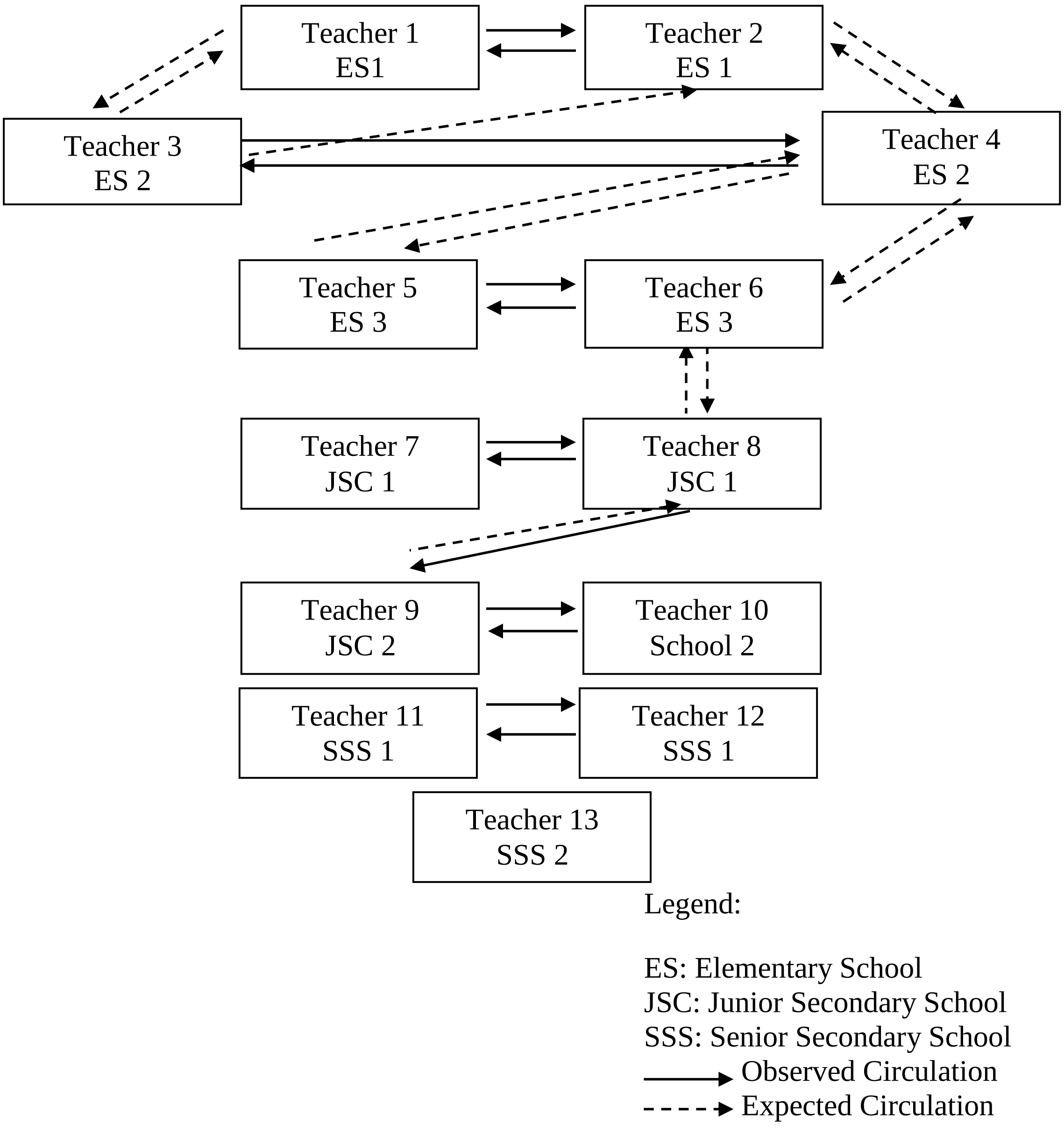


Figure 4.25 Expected Circulation of electronic maps among participating teachers

The circulation of electronic maps was observed and the links are an indication of the sharing of maps, which took place as expected by copying one mathematics teacher's electronic maps and providing it to others via a USB drive since file transfer through internet, although possible, was not favoured in this area. Based on their experiences with the electronic maps, the teachers evaluated the electronic mapping system through four short questionnaires and, face-to-face discussions with the researcher.

4.3.5 Teachers' satisfaction

Participants' satisfaction with regard to the evaluation components of the electronic mapping system as measured on a 5 point scale, give the points of the scale. Due to the low number of responses to the categories *Somewhat Satisfied* and *Not Satisfied* these were combined for evaluations of both the electronic maps and its associate readers.

As can be seen for the resource mapping tool all teachers reported some level of satisfaction with all components evaluated. As displayed in Table 4.39 the most highly rated components were the idea, function, and innovation of the electronic maps, generated through GRMaps .

Table 4.39 Teachers Satisfaction of the GRMap

Components	Satisfaction					
	Very Satisfied		Satisfied		Somewhat to Not Satisfied	
	n	%	n	%	n	%
1. Idea	11	84.6	2	15.4	0	0.0
2. Function	9	69.2	4	30.8	0	0.0
3. Innovation	9	69.2	4	30.8	0	0.0
4. File Structure	7	53.8	6	46.2	0	0.0
5. Characteristics						
Database Structure	5	38.5	8	61.5	0	0.0
Entry Data	5	38.5	8	61.5	0	0.0
Modifiable and Shareable	6	46.2	7	53.8	0	0.0

6. Implementation	1	7.7	12	92.3	0	0.0

When the components for Guidelinks, the tool to work with the GRMap, were evaluated, as revealed by Table 4.40, teachers again highly rated the components, the idea, layout, characteristics, functions, and innovation for Guidelinks.

Table 4.40 Teachers' Satisfaction of the Guidelinks, the Associate Reader

	Very Satisfied		Satisfied		Somewhat to not Satisfied	
	n	%	n	%	n	%
1. Idea	11	84.6	2	15.4	0	0.0
2. Layout of Software	9	69.2	4	30.8	0	0.0
3. Characteristics						
Connection to Electronic Maps	8	61.5	5	38.5	0	0.0
Catalogue and Search Facilities	8	61.5	5	38.5	0	0.0
One button click to visit web site	8	61.5	5	38.5	0	0.0
4. Function	8	61.5	5	38.5	0	0.0
5. Innovation	8	61.5	5	38.5	0	0.0
6. Implementation	2	15.4	10	76.9	1	7.7

Based on their experiences, the teachers evaluated the Guidelinks through a discussion with the researcher, and the questionnaire provided. Teachers' satisfaction with regard to the evaluation components of the electronic mapping system electronic map were originally measured on a 5 point scale, but were finally classified as "very satisfied", "satisfied" and the remainder "somewhat satisfied".. Results of the interviews confirmed that teachers recommended the use and sharing of the maps with other teachers, so these teachers could see how others taught the subjects. Several teachers also were interested in implementation of the tools for wide use in the Bojonegara sub district. All teachers reported some level of satisfaction with all components for the LDMap. As reported in Table Table 4.41 the highest satisfaction is for the components idea, innovation, and function, but the lowest was for the implementation.

Table 4.41 Teachers' satisfaction of the LDMap

	Very Satisfied		Satisfied		Somewhat, to Not Satisfied	
	n	%	n	%		%
1. Idea	11	84.6	2	15.4	0	0.0
2. Innovation	9	69.2	4	30.8	0	0.0
3. Function	7	53.8	6	46.2	0	0.0
4. File structure	7	53.8	6	46.2	0	0.0
5. Characteristics						
Creating curriculum-aligned and non curriculum-aligned Learning designs	6	46.2	6	46.2	1	7.7
Convert able to HTML	8	61.5	5	38.5	0	0.0
Modifiable and shareable	5	38.5	8	61.5	0	0.0
6. Implementation	4	30.8	9	69.2	0	0.0

All teachers reported some level of satisfaction with all components for the LDMap mapping learning designs as reported in Table 4.42. As for the GRMap the highest level of satisfaction was with idea, innovation and function and the lowest was with implementation. However all teachers indicated they were at least satisfied with both mapping tools.

Table 4.42 Teachers' satisfaction with the LDSoft, the Associate Reader

Components	Satisfaction					
	Very Satisfied		Satisfied		Somewhat to Not Satisfied	
	n	%	n	%	n	%
1. Idea	10	76.9	3	23.1	0	0.0
2. Innovation	8	61.5	5	38.5	0	0.0
3. Function	7	53.8	6	46.2	0	0.0
4. Characteristics						
Creating Curriculum-aligned and non Curriculum-aligned Learning Designs	6	46.2	6	46.2	1	7.7
Convertable to HTML	8	61.5	5	38.5	0	0.0
Modifiable and Shareable	5	38.5	8	61.5	0	0.0
5. Layout of Software	5	38.5	8	61.5	0	0.0
6. Implementation	2	15.4	11	84.6	0	0.0

The design and development of electronic mapping system and its implementation as explained in this section can be considered as innovation in technology-based teaching and learning for use by mathematics teachers in developing countries. In order to measure the worth of innovation, evaluation using Alexander and Hedbergs' mode was conducted in the following section.

4.4 Phase IV: Evaluation and institutionalisation of innovation

According to Alexander and Hedberg (1994, p. 241), the process of evaluation using decision-based models is conducted through four activities of 1) Design, 2) Development, 3) Teaching, and 4). Evaluation of the technology-based teaching and learning tools was addressed through the three main studies; 1) Localised study of ICT conditions in Bojonegara Sub District , Indonesia; 2) Research and development of the mapping tools and associate readers; and 3) Implementation by the 13 mathematics teachers involved in the case studies. These studies suggested that while teachers thought the tools were conceptually excellent implementation, while positively regarded, was not as highly rated as other concepts. This, together with a focus on implementation and institutionalisation in the fourth stage of evaluation led to a focus on improving usability, in terms of demonstrating widespread functionality, and through this increasing the likelihood that the tools with be sustained and maintained because of their usefulness.

The manner in which institutionalisation and usability has been investigated has been through five projects: 1) An investigation of the use of GRMap and its associate reader in hyperlearning 2) The extension of the mapping systems to be aligned to national curriculum, and 3) Demonstrate their use in curriculum review; 4) Exploration of the mapping tools in terms of developing an online embedded mathematics learning support system; and, 5) Evaluation of the documentation to ensure its modifiability in terms of making changes to GRMaps and LDMap and the associated readers;. Through these projects the need for refinement of the mapping tools or associate editors has been investigated and in some instances, the identification of useful adjunct processes has been identified. These studies involved

information gathering through formative and summative evaluation as did the earlier studies. The studies can be aligned with the Alexander and Hedberg (1994) evaluation model as presented in Table 4.43

Table 4.43 Activities of evaluation

Evaluation Stage	Information Gathering	Purposes	Questions	Name of Data	Source of Data
Design	Analysing the Needs	To provide information for planning of the development of the product.	What are characteristics of an appropriate tool for the advancement of teaching and learning of mathematics for use in developing countries?	Survey of ICT and education in developing countries. The physical state and teachers' awareness of ICT in Bojonegara Sub District , Indonesia.	Literature review Observation
	Formative Evaluation of the Design	To inform the decision made in the design of the product.	How to develop a design of tool appropriate for use in developing countries?		
Develop	Formative Evaluation of the Development	To inform decision made in the development of the technology-based teaching and learning product.	Is the electronic mapping system of mathematical learning resources and learning design is ready for use in developing countries?	The physical state and teachers' awareness ICT condition in Bojonegara Sub District, Indonesia. Tool testing	Observation Research and development
Teach	Summative Evaluation of the Tool Implementation	To determine the worth of the technology-based teaching and learning tool in the context of its use by mathematics teachers in developing countries	Is the electronic mapping system of the tool of mathematical learning resources and learning design appropriate for mathematics teachers in developing countries?	Teachers' satisfaction and evaluation of the electronic mapping system. Students' satisfaction and evaluation to the implementation of the electronic mapping systems	Teachers' experiences with electronic maps

Table 4.44 Activities of Evaluation (institutionalise)

Institutionalise	Impact Evaluation	To determine the impact of the implementation of the technology-based teaching and learning tool in developing countries	What is the impact of implementation of the electronic mapping system of the product?	Teachers’ perspective on the implementation of tool and its appropriateness for use in developing countries Students’ academic performance	1.Teachers’ experiences with electronic maps 2. Empirical study
	Maintenance Evaluation	To determine the contextual validity of the technology-based teaching and learning tool for use in developing countries	Are the tools maintainable and likely to be used in developing countries? Are there ways of extending use?	1. Teachers’ perspective on institutionalization and the future of electronic mapping system 2. Mapping an official curriculum (Indonesian) 3. Curriculum Review 4.Embedded Learning Support 5.Modifiability of the structure of Maps	1. Teachers’ experiences with electronic maps 2.Curriculum Review

The first three stages of the Alexander and Hedberg model were addressed with the design based on the identified needs of teachers in developing countries where the ICT infrastructure, facilities and resources in their schools or area were generally poor. In the development phase analysis of data from a sample of 119 teachers in Indonesia revealed that teachers need an appropriate approach, software, or system that is consistent with ICT capabilities in their area. These needs reflected the use of their own computers, and did not simply rely on their school or institutional ICT infrastructure that would in a developing country would be considered inadequate. The software proposed was intended to support teachers in accessing many mathematical learning resources on the internet and to support teachers documenting and sharing their learning designs with others. Thus it is expected that the software is suitable for use in developing countries. During the teaching phase case studies with 13 mathematics teachers led to the conclusion based on teachers' satisfaction and evaluation of the tools components that these products are appropriate for use by teachers to share learning designs and resources.

The focus in this section therefore is on the fourth of these stages institutionalisation. The initial data to address implementation was gathered from the 13 case studies of mathematics teachers as shown in Table 4.45, approximately 76.9 percent of mathematics teachers agree, with a further 23.1 percent strongly agreeing, that the implementation, impact, and sustainability of the use of the tools by teachers in the long term is good. This bodes well for being able to embed the tools at an institutional level, rather than the one-off use by individual teachers

Table 4.45 Implementation, benefits, appropriateness, institutionalisation, and usability

No	Components	Evaluation					
		Strongly Agree		Agree		Neutral to Strongly Disagree	
		n	%	n	%	n	%
1	Beneficial for						
	a) Teachers	9	69.2	4	30.8	0	0.0
	b) Students	9	69.2	4	30.8	0	0.0
	c) School	9	69.2	4	30.8	0	0.0
	d) Community in general	9	69.2	4	30.8	0	0.0
2	Appropriate to current ICT condition	6	46.2	7	53.8	0	0.0
3	Institutionalization						
	a) Implementation	3	23.1	10	76.9	0	0.0
	b) Impact	3	23.1	10	76.9	0	0.0
	c) Self-managed for a long term	3	23.1	10	76.9	0	0.0
4	Easy to use	2	15.4	11	84.6	0	0.0

All teachers considered the tools appropriate for use in developing countries, appropriate in terms of the ICT available and appropriate for use by mathematics teachers in these countries. Teachers expressed an agreement for the technology-based tools for mass produced, implemented by schools and for institutionalized.

Table 4.46 Implementation – appropriateness for use in developing countries

No	Aspects	Evaluation					
		Strongly Agree		Agree		Neutral to Strongly Disagree	
		n	%	n	%	n	%
1	Appropriateness for Use in Developing Countries						
	a) Appropriate to current ICT	8	61.5	5	38.5	0	0.0
	b) Appropriate for use by mathematics teachers	7	53.8	6	46.2	0	0.0
	c) Recommended for mass produced	6	46.2	7	53.8	0	0.0
	d) Could be implemented by schools	5	38.5	8	61.5	0	0.0
	e) Could be institutionalized	3	23.1	10	76.9	0	0.0

Complete examination of electronic mapping system institutionalization may take a long time, beyond the limited duration of this research project, however indications

of a good prospect of institutionalization have been gained through data collected during the case studies of 13 mathematics teachers using the tools. The current results revealed that teachers were more enamoured of the concept than they were the usability (refer Table 4.45 and 4.46). While the concept was highly rated, the implementation and usability was not. This lead the researcher into the next phase of research and focus of Chapter 5, namely, improving usability

CHAPTER 5. IMPROVING USABILITY

Much of the initial investigation focussed on the design, development and implementation of software mapping tools, whereas this chapter furthers research, after a review of the results of studies suggested that usability of the mapping tools could be improved. Teachers were more enamoured of the concept than they were the usability. Therefore in terms of implementation and institutionalisation further work has been undertaken to address the usability of the tools. This has included a study of the use of the tools in hyperlearning by students; demonstration of how to align the electronic mapping system with official curricula (Indonesian context); curriculum review by educators (Australian context), the development of embedded mathematics learning support systems (Australian context); and examination of the documentation that permits users to use and modify the tools.

5.1 Introduction

The results of the 13 teacher case studies suggested that teachers were more enamoured of the concept than they were the usability of the software mapping tools. Therefore in terms of implementation and institutionalisation further work has been undertaken to extend the use of the electronic system in order to improve its usability and prospects for continued use.

Usability is dependent upon the design of the tool, in relation to users, the task, and the environment, and upon the success of user support (Shackel in Heaton, 1992). There are four main components of usability as defined by Shackel: 1) Effectiveness, how effective is the user with the product, 2) Learnability, how easy is it to learn/relearn to use the product, 3) Flexibility, how flexible is the product, and 4) Attitude, and how comfortable/satisfied are users with the product. In the case of the electronic mapping system, its usability could be improved by considering these components. Actions such as improving functionality of the tools in response to user requests improves effectiveness, documentation directly impacts on how easy it is to learn to use the tools, while expanding the usefulness of the tools lends itself to be a flexible tool. These actions expanding the tools functionality, learnability and flexibility should lead to an expanded culture of use as it becomes more useful and easier for users because other users around them are also use it. In terms of Alexander and Hedberg's evaluation model (1994), through these improvements, the tools are more likely to result in institutionalisation or embedding of the tools into ongoing institutional use.

The initial focus in terms of institutionalisation has primarily been through demonstrating the flexibility of the tools in terms of an extended the range of uses and refining the tools as new functions have been implemented. Demonstrations have included 1) The use of the tools in hyperlearning by students; 2) Alignment of the electronic maps with official curricula (Indonesian context), 3) Curriculum review by educators, and 4) The development of embedded mathematics learning support systems. The aspect of usability and learn ability, is addressed through

documentation refinement, testing and making documentation available online together with the tools.

5.2 Hyperlearning

The tools were developed with two primary functions in mind, the mapping of resources and learning designs. The emphasis was on assisting teachers in the development of their teaching. In terms of demonstrating additional usability, this study in hyperlearning involved a comparison of conventional methods for learning mathematics and learning methods made possible through current developments in information and communication technology to explore the potential for use of the GRMap tool as an alternative teaching strategy. These ICT developments include improved internet access, with the internet becoming widely accessible from villages and rural areas of Indonesia as well as cities and with greatly increased speed of internet access and a proliferation of web sites containing learning resources materials and web 2.0 technologies allowing people to exchange and share knowledge, information and ideas, easily and rapidly.

According to the seminal book by Perelman (1992) hyperlearning relates to a technological revolution. Perelman (1992, p. 27-28) described four key technological threads of hyperlearning: 1) the smart environment, where every artefact is endowed with intelligence, 2) a “telecosm” communication infrastructure that makes all knowledge accessible to anyone, anywhere, anytime, 3) a kit of “hypermedia” tools for navigating through a knowledge-dense universe, and 4) brain technology These technological threads support people through the availability of supporting smart environments, communication infrastructure to have knowledge accessible anywhere and anytime, the availability tools to navigate the knowledge-dense universe, and the technology that may influence peoples’ brains through providing new and interesting knowledge easily.

Research regarding effective hyperlearning addresses a number of issues. Early work Unz & Hesse (1999) focussed on how hypertext could be used in learning. While

Lyytine, Rose, & Yoo (2002) examined different strategies for the execution of hyperlearning, specifically they addressed how organizations can re-configure their learning capability to match different learning demands. Barbera (2006) focussed on developing a distributed and semantically structured e-research and e-learning platform, while Mason (2007) discussed the shift from hyperteaching to hyperlearning and the different modes of interaction that can be implemented with e-screens.

An electronic mapping system can act as a tool to navigate through a knowledge-dense internet. The use of the mapping tools can enable people especially students at university or school, to conduct hyperlearning, that is to navigate the knowledge-dense universe of mathematical learning resources in the internet in more effective ways than is currently possible. Thus the electronic mapping system developed in this thesis is one tool that can increase access to and allow use of the ideas of mathematics located in the internet

Hyperlearning can be conducted by students without guidance to designated learning resources, which means students navigate through the World Wide Web to access a variety of learning resources available on the internet at anytime and anywhere by themselves without guidance from teacher or lecturer about which resources should be obtained or where they should be obtained from. The students can access resources by using search engines such as Google, Bing, and others or by remembering the web addresses (for example by typing Wikipedia.org in the web browser address). This method of learning may be termed *unguided hyperlearning* (UH). One potential benefit of *unguided hyperlearning* is that there will be a variety of different learning resources accessed and used by students which are not dependent on those provided by teachers and lecturers. With *unguided hyperlearning* the teacher only provides topics and subtopics to students, and the students engages in hyperlearning by locating resources, and saving the location themselves and using them to complete their studies. Through *unguided hyperlearning* students will have different access to resources on the internet depending upon their knowledge and experience of the web, however students may also spend much time locating and

reviewing irrelevant resources and the quality and validity of the resources could be questioned since the resources are not necessarily teacher reviewed.

As illustrated in Figure 5.1, through the implementation of an electronic mapping system, students can be provided with guided access to and use of available learning resources via the internet using pre-constructed electronic maps which retain the link to the web. Thus students are able to navigate through a charted knowledge-dense World Wide Web, by themselves. For this reason, the method of learning is called *guided hyperlearning* (GH). The benefit of this method lies in the provision of quality and teacher verified resources, mapped in modifiable and shareable electronic maps, before being provided to students. The number and quality of the learning resources provided in the maps will depend on the teachers' knowledge and at some point research regarding the optimal number of resources. To increase this available number, other teachers' electronic maps and experiences of resources also can be used.

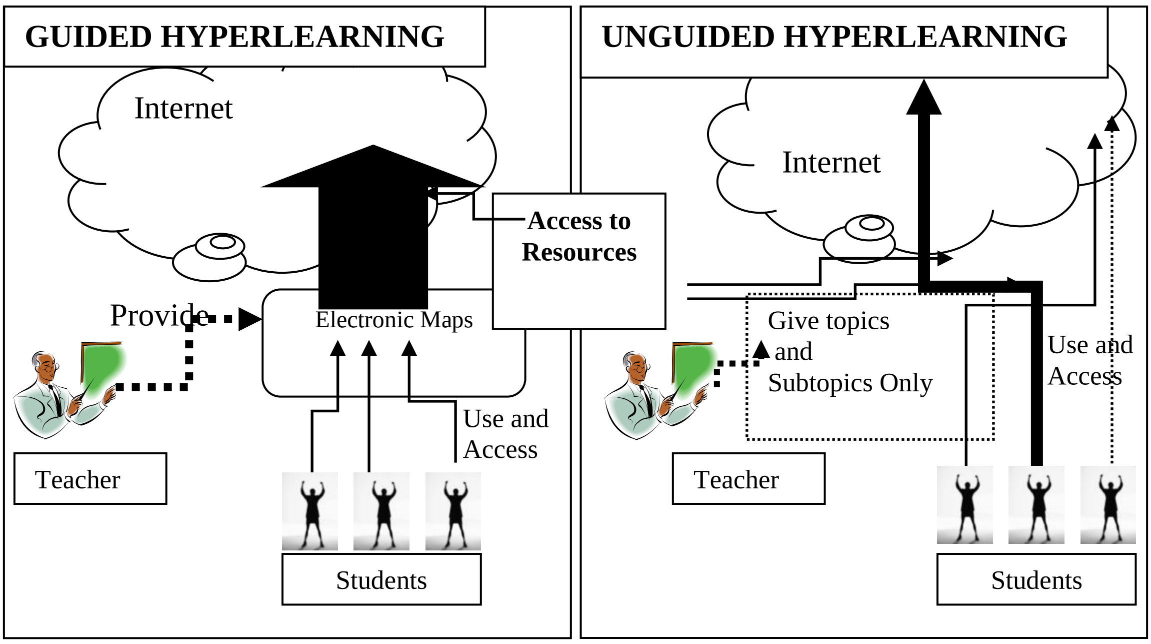


Figure 5.1 Concept of Guided and Unguided Hyperlearning

In this section, the use of guided hyperlearning (GH) and unguided hyperlearning (UH) as alternatives to conventional learning (CL), where students receive lectures and solve mathematics problems together in groups is examined.

5.2.1 Experimental design

Three classes with a total of 115 students participated in this research, with Group A, Group B, and Group C based on the regular allocated first year university student classes. Each group was taught three topics, *Number Systems*, *Functions* and *Graphing*, and each group experienced a different treatment, that is method of instruction, GH, UH and CL, for each topic. Each topic involved subtopics as indicated in Table 5.1

Table 5.1 Sequencing of topics and experimental conditions.

Topic: Number System	Topic: Functions	Topic: Graphing
Subtopics: History of Number Natural Numbers Rational Numbers Arithmetic Operations Special topics	Subtopics: Definition and Examples Operations Composition of Functions Special Functions Graphics of Functions	Subtopics: Cartesian Coordinates (2-D) Polar Coordinates (2-D) Cartesian Coordinates (3-D) Polar Coordinates (3-D) Graphics with Parameters

Each treatment was conducted within a two week period. Pre-test and post-test evaluation involved comparing both performance and students' satisfaction measures given the teaching method. The sequencing of pre-tests, topics taught and post-testing for each of three groups is illustrated in Table 5.2

Table 5.2 Sequencing of tests and topics by treatment

Group	Pre-test observation all topics	Topic Number Systems	Post-test Observation (O)	Topic Functions	Topic Graphing	Post-test Observation
A	O_{NFG}	CL	O_N	GH	UH	O_{FG}
B	O_{NFG}	GH	O_N	UH	CL	O_{FG}
C	O_{NFG}	UH	O_N	CL	GH	O_{FG}

Pre-tests for each topic were conducted together in the first meeting of each class. While the post-tests were initially scheduled to be conducted at the end of each topic taught, after the first post-test for *Number Systems* it was decided given student requests, to reduce the student burden of frequent testing and to test the last two topics, functions and graphing, together.

In this research, each topic has different characteristics, cognitive, psychomotor, and combination of cognitive and psychomotor, with the interest in comparison based on the topics in general, not subtopics. For that reason one pre- or post-test question may cover one or more subtopics, and one subtopic may be included in one or more pre or post-test questions.

Pre-tests and post-tests sets of questions on the topic of learning (refer Table 5.1), were not equivalent in difficulty, with the post-test set harder than the pre-test, and the analysis undertaken on the difference in scores (post-test - pre-test mark). For example for questions in Table 5.3, the pre-test fractions question simply involves solution from right to left, but the post-test requires students to draw upon their knowledge of the order of operations completing multiplication and division before the addition and subtraction.

Table 5.3 An example of one question covered two subtopics

Pre-test question	Post-test question
Calculate $\frac{1}{2} x \frac{1}{2} \div \frac{1}{4} - \frac{1}{4}$	Calculate $\frac{1}{5} + \frac{1}{3} - \frac{2}{5} x \frac{1}{4} \div \frac{20}{2}$

While for the topic graphing, the pre-test, students were asked to graph the functions $y(x) = x^2+2$ while in the post-test they were asked draw a graph of the function y(x)= 2 Sin (x) + 1. The two questions are similar, however, in practice the post-test question is likely to be harder for students because they need additional knowledge in trigonometry.

Table 5.4 Comparison of pre-test and post-test questions in topic Graphing

Pre-test question	Post-test question
Draw graphics of function $y(x) = x^2+2$	Draw graphics of function y(x) = 2 Sin (x) + 1

5.2.2 Participants

The experiment took place over half a semester, eight weeks from February to April 2012, and was conducted in three phases. Of the 115 first year university students participating in this research 43 were in Group A (10 male and 33 female), 39 in Group B (7 male and 32 female) and 33 in Group C (8 male and 24 female). While the students were not randomly allocated to groups there were no identifiable significant differences between classes on several characteristics. There was no significant difference in mean age ($F_{(2,112)}$=0.548, p=0.58) with average age of all students 18.6 years. Overall 80.9 per cent of students reported having excellent or good computer skills versus having bad or poor skills with there being no significant

difference in the proportions of students in each group having excellent or good computer skills (χ^2=1.63, df=2, p-value=0.442). There was no significant difference between classes in the ownership of computer devices, (χ^2=3.78, df=4, p-value=0.437), with the Notebook type of computer the most common (48.7 per cent), followed by Netbook (21.7 per cent) and the remaining without Notebook or Netbook (29.6 per cent). There was no significant difference between classes in the proportion of students who accessed the internet up to 3 hours per day (76.5 per cent) versus more than 3 hours per day (χ^2=2.54, df=2, p-value=0.280). The dominant mode of connection to the internet was through the USB GSM Model (51.3 per cent). Again there was no significant difference in the proportion of students from the three classes accessing the internet by USB compared to all other possible methods, such as Wifi, Internet Cafe (χ^2=0.187, df=2, p-value=0.911).

Teaching mathematics at university is undertaken in Bahasa, the Indonesian language. However some learning resources were available in English, and in Indonesia for tertiary schools it is common for resources to be provided in English. The dominant language for presentation of learning materials in the internet is also in English. For this reason information about students' English skills was also collected. Overall 31.3 per cent of students reported having excellent or good English skills with there being no significant difference in the proportions of students in each class having excellent or good English skills compared to those classified as having with poor or bad (χ^2 =1.18, df=2, p-value=0.555). In addition, overall 41.7 per cent of students reported having a formal English course outside university with there being no significant difference in the proportions of students in each group having a formal English course outside university (χ^2 =0.19, df=2, p-value=0.910).

5.2.3 Analysis of the process of learning

Initially, the process of learning was investigated for each of the three topics, *Number Systems*, *Functions* and *Graphing*, according to the teaching method, GH, UH or CL. Students in conventional learning were asked to self-rate the amount

mathematics learned or acquired through the lecturing approach. Students in the guided hyperlearning were supplied with the electronic mapping system containing hyperlinks to trusted resources, that is resources verified by lecturers to have content that is accurate for each topic and subtopic. Data collected simply indicated whether or not students accessed one or more sites versus no sites. The students in the unguided hyperlearning group were supplied only with list of topics and subtopics and were asked to provide one hyperlink that they used to learn each subtopic.

5.2.3.1 Topic 1, Number Systems

For Topic 1, *Number Systems*, the CL students received lectures, the students in UH were given list of topics and subtopics of *Number Systems*, while students in the GH group were provided with an electronic map of learning links to sites for each of the subtopics. Resources were in Indonesian and English according to the origin of the site, although data were not collected regarding which site the students accessed.

Table 5.5. List of resources for Topic 1 Number taught by guided hyperlearning

No	Topic and Subtopic	Name of Resources	Web Address	Geographic Location
1	Number System: History	1. Mac Tutor history of math	www.st-and.ac.uk	Scotland
2		2. Number	www.wikipedia.org	USA
3		3. History of number	www.maths.org	USA
4	Number System: Natural Number	1. *Jenis bilangan sederhana*	www.crayonpedia.org	Indonesia
5		2. Natural number	www.wikipedia.org	USA
6		3. Natural number	www.wolfram.com*	USA
7	Number System: Rational Number	1. *Jenis bilangan sederhana*	www.crayonpedia.org	Indonesia
8		2. Rational number	www.wikipedia.org	USA
9		3. Rational number	www.wolfram.com*	USA
10	Number System: Arithmetic Operation	1. *Operasi Bilangan*	www.crayonpedia.org	Indonesia
11		2. Arithmetic Operation	www.wikipedia.org	USA
12		3. Arithmetic	www.wolfram.com*	USA
13	Number System: Special Topics	1. *Operasi bilangan*	www.crayonpedia.org	Indonesia
14		2. Number	www.wikipedia.org	USA
15		3. Bentuk Aljabar	www.crayonpedia.org	Indonesia

Although they belong to companies' or personal websites (.com), researcher has confirmed that the resources from these websites are trusted resources.

An examination of self-ratings for the CL group in Table 5.7 revealed that no students self-rated their acquisition of knowledge during CL method as excellent for

any of the subtopics. The average percentage of student rating CL over each subtopic, resulted in students rating their acquisition of *Natural Numbers* via CL as good (24.65%), fair (64.19%), poor (9.77%) or bad (1.40%).

The data for GH reveals the number of guided learning links used for each sub-topic and in Table 5.7 it is evident that a large number of students used no sites. For the subtopic *Special topics* only six students (15.4%) accessed one or more sites compared to *Natural Numbers* where 31 (79.5%) of students accessed at least one site.

The data for UH reveals the list of trusted and untrusted sites used by students to learn the subtopics (refer Table 5.6) and in Table 5.7 it is evident that although all students used at least one site, a large number of students did not use trusted sites. For the subtopic *History* only nine sites (21.2%) compared to *Special topics* where 14 (39.4%) sites were trusted sites. Whereas the use of sites that were not trusted ranged from 19 sites (60.6%) for subtopic *Special Topic*s to 22 sites (78.8%) for the subtopic *History*.

Table 5.6. List of hyperlinks used in UH in Topic 1, Number Systems

		Sub-topics				
Status	Category	1. History	2. Natural Number	3. Rational Number	4. Arithmetic Operation	5. Special Topics
Trusted	Educational Institutions	gunadarma.ac.id (3.0%)*	ittelkom.ac.id (3.0%)	colorado.edu (12.1%)	upi.ac.id (12.1%) ui.ac.id (9.1%) uns.ac.id (3.0%)	its.edu (12.1%)
	Online Encyclopaedia	crayonpedia.org (12.1%) wikipedia.org (6.1%)	crayonpedia.org (21.2%) wikipedia.org (12.1%)	wikibooks.org (9.1%) crayonpedia.org (3.0%) wikipedia.org (3.0%)	crayonpedia.org (3.0%)	crayonpedia.org (27.3%)
	Total Trusted	21.2%	36.3%	27.2%	27.2%	39.4%
Not trusted	Organization, Company, or Personal Provider	eduklinik.info (45.5%) anchota.com (3.0%)	eduklinik.info (12.1%) belajar-matematika.com (6.1%) matematikamenyenangkan.com (3.0%) preceptorial.com (3.0%)	multiply.com (12.1%) belajar-matematika.com (3.0%) mascipul.com (3.0%) shvoong.com (3.0%)	aurino.com (12.1%) belajar-matematika.com (6.1%)	jogjakarta.go.id (21.2%) faktailmiah.com (6.1%) matematika.us (6.1%) psb-prisma.org (3.0%) soalmatematika.com (3.0%)
	Blog	blogspot.com (9.1%) wordpress.com (9.1%)	wordpress.com (15.2%) blogspot.com (3.0%)	blogspot.com (6.1%) wordpress.com (6.1%)	wordpress.com (36.4%) blogspot.com (3.0%)	blogspot.com (6.1%) wordpress.com (6.1%)
	File sharing	scribd.com (12.1%)	scribd.com (21.2%)	fileeden.com (15.2%) 4shared.com (9.1%) scribd.com (6.1%) slideshare.net (3.0%)	scribd.com (12.1%) slideshare.net (3.0%)	scribd.com (6.1%) file-edu.com (3.0%)
	Total Not Trusted	78.8%	63.7%	77.8%	77.8%	60.6%

Table 5.7. Process of Learning in Topic 1: Number Systems

		Class		
		A	B	C
	Method	CL (n=43)	GH (n=39)	UH (n=33)
SUB TOPICS	History	Students' self ratings: Excellent: 0 (0.0%) Good: 6 (14.0%) Fair: 26 (60.5%) Poor: 10 (23.3%) Bad: 1 (2.3%)	Of the three designated mathematical learning sites provided: 16 (41.0%) accessed at least one designated mathematical learning resources site.	Over all students a total 8 different sites were chosen to examine the subtopic: 9 students (21.2%) used trusted sites while 22 students (78.8%) used untrusted sites.
	Natural Numbers	Students' self ratings: Excellent: 0 (0.0%) Good: 2 (4.7%) Fair: 40 (93.0%) Poor: 1 (2.3%) Bad: 0 (0.0%)	Of the three designated mathematical learning sites provided: 31 (79.5%) accessed at least one designated mathematical learning resources site.	Over all students a total 14 different sites were chosen to examine the subtopic: 16 students (36.3%) used trusted sites while 17 students (63.7%) used untrusted sites.
	Rational Numbers	Students' self ratings: Excellent: 0 (0.0%) Good: 22 (51.2%) Fair: 19 (44.2%) Poor: 2 (4.7%) Bad: 0 (0.0%)	Of the three designated mathematical learning sites provided: 7 (17.9%) accessed at least one designated mathematical learning resources site.	Over all students a total 14 different sites were chosen to examine the subtopic: 12 students (27.2%) used trusted sites while 11 students (72.8%) used untrusted sites.
	Arithmetic Operations	Students' self ratings: Excellent: 0 (0.0%) Good: 17 (39.5%) Fair: 23 (53.5%) Poor: 3 (7.0%) Bad: 0 (0.0%)	Of the three designated mathematical learning sites provided: 25 (64.1%) accessed at least one designated mathematical learning resources site.	Over all students a total 10 different sites were chosen to examine the subtopic: 12 students (27.2%) used trusted sites while 11 students (72.8%) used untrusted sites.
	Special Topics	Students' self ratings: Excellent: 0 (0.0%) Good: 6 (14.0%) Fair: 30 (69.8%) Poor: 5 (11.6%) Bad: 2 (4.7%)	Of the three designated mathematical learning sites provided: 6 (15.4%) accessed at least one designated mathematical learning resources site.	Over all students chose a total 11 different sites to examine the subtopic: 14 students (39.4%) used trusted sites while 9 students (61.6%) used untrusted sites.

For guided hyperlearning, a comparison of the mean marks of students who accessed at least one website compared to the mean marks of students who did not access any sites showed no significant difference (t=1.776, df=37, p-value=0.084) in marks compared to those who did not access links. It may be that students who did not access a site felt they knew a given topic or subtopic. Data was not available to check this. Data regarding student performance on the subtopics was not available because the questions initially were designed to compare topics not subtopics. In this

condition, one subtopic was assessed in more than one questions, while two subtopics were assessed in the other question with only the total test mark being retained for analysis.

5.2.3.1 Topic 2, Functions

For Topic 2, *Functions*, the CL students received lectures, the students in UH were given list of topics and subtopics of *Functions*, while students in the GH group were provided with an electronic map of learning links (refer Table 5.8) to sites for each of the subtopics. Resources were again in Indonesian and English according to the origin of the site.

Table 5.8. List of resources for Topic 2 Functions taught by guided hyperlearning

16	Functions: Definitions	1. *Matematika*	www.crayonpedia.org	Indonesia
17		2. Functions (Mathematics)	www.wikipedia.org	USA
18		3. Functions	www.wolfram.com*	USA
19	Functions: Operations	1. *Matematika*	www.crayonpedia.org	Indonesia
20		2. Functions (Mathematics)	www.wikipedia.org	USA
21		3. Functions	www.wolfram.com*	USA
22	Functions: Compositions	1. *Matematika*	www.crayonpedia.org	Indonesia
23		2. Functions (Mathematics)	www.wikipedia.org	USA
24		3. Functions	www.wolfram.com*	USA
25	Functions: Special Functions	1. *Matematika*	www.crayonpedia.org	Indonesia
26		2. Functions (Mathematics)	www.wikipedia.org	USA
27		3. Functions	www.wolfram.com*	USA
28	Functions: Graphics of Functions	1. *Matematika*	www.crayonpedia.org	Indonesia
29		2. Functions (Mathematics)	www.wikipedia.org	USA
30		3. Functions	www.wolframalpha.com*	USA

Although they belong to companies' or personal websites (.com), researcher has confirmed that the resources from these websites are trusted resources.

An examination of self-ratings for the CL group for the topic *Functions* in Table 5.10 revealed that only one student self-rated their acquisition of knowledge during CL method as excellent for subtopics *Graphics of Functions*. The average percentage of student rating CL over each subtopic, resulted in students rating their acquisition of *Functions* via CL as excellent (0.61%), good (29.10%), fair (60.61%), poor (9.70%) and bad (0%).

The data for GH reveals the number of guided learning links used for each subtopic and in Table 5.10 it is evident that a large number of students used no sites. For the subtopic *Graphics of functions* only three students (7.0%) accessed one or more sites compared to *Definition* where 9 (20.9%) of students accessed at least one site.

The data for UH reveals the list of trusted and not trusted sites used by students to learn the subtopics (refer Table 5.9). While all students used at least one site per subtopic from Table 5.10 it is evident that a large number of students used sites that were not trusted. For the subtopic *Composition of functions* and *Special functions* only 12 sites (30.9%) compared to *Operations* where 24 sites (71.9%) were trusted sites. Whereas the use of sites that were not trusted ranged from 15 sites (28.1%) for subtopic *Operation* to 27 sites (69.1%) for the subtopic *Composition of functions* and *Special functions*.

Table 5.9. List of hyperlinks used in UH in Topic 2, Functions

		Sub-topics				
Status	Category	1. Definition and examples	2. Operation	3. Composition of functions	4. Special functions	5. Graphics of functions
Trusted	Educational Institutions	gunadarma.ac.id (15.4%) ittelkom.ac.id (12.9%) p4tkmatematika.org (10.3%) itb.ac.id (2.6%) ui.ac.id (2.6%) ukdw.ac.id (2.6%)	unsyiah.ac.id (23.1%) p4tkmatematika.org (17.9%) ittelkom.ac.id (7.7%) ui.ac.id (7.7%) akprind.ac.id (2.6%) gunadarma.ac.id (2.6%) uns.ac.id (2.6%)	p4tkmatematika.org (17.9%) ui.ac.id (7.8%) uns.ac.id (2.6%)	ui.ac.id (15.4%) p4tkmatematika.org (10.3%) ukdw.ac.id (5.1%) uns.ac.id (5.1%)	ui.ac.id (12.8%) p4tkmatematika.org (10.9%) its.edu (2.6%) uns.ac.id (2.6%)
	Online Encyclopaedia	crayonpedia.org (10.3%) wikipedia.org (10.3%)	crayonpedia.org (7.7%)	crayonpedia.org (2.6%)		wikipedia.org (2.6%)
	Total Trusted	67.0%	71.9%	30.9%	35.9%	31.5%
Not trusted	Organization, Company, or Personal Provider	perpusonline.com (10.3%) bimbinganbelajar.net (5.1%) eduklinik.info (5.1%)	perpusonline.com (10.3%) tentangcad.com (2.6%)	bimbinganbelajar.net (25.6%) belajar-matematika.com (10.3%) mascipul.com (2.6%) mathzone.web.id (2.6%)	bimbinganbelajar.net (10.3%) aurion.com (2.6%) forumsains.com (2.6%) mathematica.com (2.6%)	matematika.us (12.8%) e-dukasi.net (7.7%) jogjakarta.go.id (2.6%) oke.or.id (2.6%)
	Blog	wordpress.com (2.6%)	wordpress.com (7.7%) blogspot.com (2.6%)	wordpress.com (10.3%) blogspot.com (2.6%)	blogspot.com (12.8%) wordpress.com (10.3%)	
	File sharing	ebookdatabase.net (10.3%)	scribd.com (5.1%)	ebookdatabase.net (10.3%) scribd.com (5.1%)	scribd.com (20.5%) docstoc.com (2.6%)	scribd.com (43.6%)
	Total Untrusted	33.0%	28.1%	69.1%	64.1%	68.5%

Table 5.10. Process of Learning in Topic 2: Functions

		Class		
		A	B	C
	Method	GH (n=43)	UH (n=39)	CL (n=33)
SUB TOPICS	Definition	Students were provided with three sites, 9 (20.9%) students accessed at least one designated mathematical learning resource site.	Over all students a total 13 different sites were chosen to examine the subtopic: 9 students (67.0%) used trusted sites while 30 students (34.0%) used untrusted sites.	Students' self ratings Excellent: 0 (0.0%) Good: 24 (72.7%) Fair: 9 (27.3%) Poor: 0 (0.0%) Bad: 0 (0.0%)
	Operation	Students were provided with three sites, 7 (16.3%) accessed at least one designated mathematical learning resource site.	Over all students a total 13 different sites were chosen to examine the subtopic: 16 students (71.9%) used trusted sites while 23 students (28.1%) used untrusted sites.	Students' self ratings: Excellent: 0 (0.0%) Good: 14 (42.4%) Fair: 19 (57.6%) Poor: 0 (0.0%) Bad: 0 (0.0%)
	Composition	Students were provided with three sites, 6 (14.0%) accessed at least one designated mathematical learning resource site.	Over all students a total 12 different sites were chosen to examine the subtopic: 11 students (30.9%) used trusted sites while 28 students (69.1%) used untrusted sites.	Students' self ratings: Excellent: 0 (0.0%) Good: 5 (15.2%) Fair: 26 (78.8%) Poor: 2 (6.1%) Bad : 0 (0.0%)
	Special Functions	Students were provided with three sites, 4 (9.3%) accessed at least one designated mathematical learning resource site.	Over all students a total 12 different sites were chosen to examine the subtopic: 14 students (35.9%) used trusted sites while 25 students (64.1%) used untrusted sites.	Students' self ratings: Excellent: 0 (0.0%) Good: 2 (6.1%) Fair: 26 (78.8%) Poor: 5 (15.2%)
	Graphic and Functions	Students were provided with three sites, 3 (7.0%) accessed at least one designated mathematical learning resource site.	Over all students chose a total 10 different sites to examine the subtopic: 12 students (31.5%) used trusted sites while 27 students (68.5%) used untrusted sites.	Students' self ratings: Excellent: 1 (3.0%) Good: 3 (9.1%) Fair: 20 (60.6%) Poor: 9 (27.3%) Bad: 0 (0.0%)

For guided hyperlearning, a comparison of the mean marks of students who accessed at least one website compared to the mean marks of students who did not access any sites showed no significant difference (t=1.858, df=41, p-value=0.070) in marks compared to those who did not access links. As for the *Number System* topic, data regarding student performance on the subtopic performance was not available

because the questions were designed to compare topics not subtopics. In this condition, one subtopic was assessed in more than one question, while another two subtopics were assessed together in one question, with only total test mark retained. Thus it was not possible to delve into whether or not there was a relationship between accessing a site and pre-test knowledge.

5.2.3.3 Topic 3, Graphing

For Topic 1, *Graphing*, the CL students received lectures, the students in UH were given list of topics and subtopics of *Graphing*, while students in the GH group were provided with an electronic map of learning links (refer Table 5.11) to sites for each of the subtopics. Resources were only in English

Table 5.11. List of resources for Topic 3 *Graphing*, taught by guided hyperlearning

31	*Graphing*: Cartesian Coordinate (2-D)	1. Graphing tool	www.fooplot.com*	USA
32		2. Cartesian Coordinate System	www.wikipedia.org	USA
33		3. Graphing tool	www.wolframalpha.com*	USA
34	*Graphing*: Polar Coordinate (2-D)	1. Graphing tool	www.analyzemath.com*	USA
35		2. Polar Coordinate System	www.wikipedia.org	USA
36		3. Graphing tool	www.wolframalpha.com*	USA
37	*Graphing*: Cartesian Coordinate (3-D)	1. 3-D Coordinate System	www.utk.edu	USA
38		2. Graphing tool	www.rechneronline.de*	USA
39		3. Graphing tool	www.wolframalpha.com*	USA
40	*Graphing*: Polar Coordinate (3-D)	1. Polar Coordinate System	www.wikipedia.org	USA
41		2. Generating polar and parametric plot	www.wolframalpha.com*	USA
42		3. Graphing tool	www.wolframalpha.com*	USA
43	*Graphing*: Graphics with Parameters	1. Plot (Graphics)	www.wikipedia.org	USA
44		2. Generating polar and parametric plot	www.wolframalpha.com*	USA
45		3. Graphing tool	www.wolframalpha.com*	USA

Although they belong to companies' or personal websites (.com), researcher has confirmed that the resources from these websites are trusted resources.

An examination of self-ratings for the CL group in Table 5.13 revealed that one student self-rated their acquisition of knowledge during CL method as excellent for subtopics *Cartesian Coordinates (2-D), Polar Coordinates (2-D),* and *Polar Coordinate (3-D)*, and two students for *Graphics with parameters*. The average percentage of student rating CL over each subtopic, resulted in students rating their acquisition of *Graphics* via CL as excellent (3.03%), good (32.73%), fair (54.54%), poor (24.85%) and bad (3.03%).

The data for GH reveals the number of guided learning links used for each sub-topic and in Table 5.13 it is evident that a large number of students used no sites. For the subtopic *Polar Coordinate (2-D)* only six students (18.2%) accessed one or more sites compared to *Cartesian Coordinates* where 21 (63.6%) of students accessed at least one site.

The data for UH reveals the list of trusted and not trusted sites used by students to learn the subtopics (refer Table 5.12) and in Table 5.13 it is evident while all students used at least one site, that a large number of students used sites not trusted. For the subtopic *Polar Coordinates (2-D)* only five sites (11.7%) compared to *Cartesian Coordinates (2-D)* where 39 sites (90.7%) were trusted sites. Whereas the use of sites that were not trusted ranged from four sites (9.3%) for subtopic *Cartesian coordinates* to 38 sites (88.3%) for the subtopic *Polar coordinates*.

Table 5.12. List of hyperlinks used in UH in Topic 3, Graphing

		Sub-topics				
Status	Category	1. Cartesian Coordinate (2-D)	2. Polar Coordinate (2-D)	3. Cartesian Coordinate (3-D)	4. Polar Coordinate (3-D)	5. Graphics with parameters
Trusted	Educational Institutions		p4tkmatematika.org (4.7%) unesa.ac.id (2.3%)	colorado.edu (9.3%) p4tkmatematika.org (2.3%) um.ac.id (2.3%)	upi.ac.id (60.5%) uns.ac.id (18.6%) ui.ac.id (9.3%) p4tkmatematika.org (2.3%)	its.edu (86.0%) ui.ac.id (2.3%)
	Online Encyclopaedia	wikipedia.org (58.1%) crayonpedia.org (25.6%)	crayonpedia.org (4.7%)			crayonpedia.org (2.3%)
	Total Trusted	83.7%	11.7%	13.9%	90.7%	90.7%
Not trusted	Organization, Company, or Personal Provider	eduklinik.com (7.0%) perpusonline.com (4.7%) weebly.com (2.3%)		analyzemath.com (2.3%)	forumsains.com (2.3%)	faktailmiah.com (4.7%) jogjakarta.go.id (2.3%) matematika.us (2.3%)
	Blog	wordpress.com (2.3%)	wordpress.com (4.7%)	blogspot.com (79.1%)	blogspot.com (2.3%) wordpress.com (2.3%)	
	File sharing		scribd.com (83.7%)	ebookdatabase.net (4.7%)	scribd.com (2.3%)	
	Total Untrusted	16.3%	88.3%	86.1%	9.3%	9.3%

Table 5.13. Process of Learning in Topic 3: Graphing

		Class		
		A	B	C
	Method	UH (n=43)	CL (n=?)	GH (n=33)
SUB TOPICS	Cartesian Coordinates (2-D)	Over all students a total 13 different sites were chosen to examine the subtopic: 36 students (83.7%) used trusted sites while seven students (16.3%) used untrusted sites.	Students' self-ratings: Excellent: 1 (2.6%) Good: 14 (35.9%) Fair: 24 (61.5%) Poor: 0 (0.0%) Bad: 0 (0.0%)	Of the three designated mathematical learning sites provided: 21 (63.6%) accessed at least one designated mathematical learning resource site.
	Polar Coordinates (2-D)	Over all students a total 13 different sites were chosen to examine the subtopic: 5 students (11.7%) used trusted sites while 38 students (88.3%) used untrusted sites.	Students' self ratings: Excellent: 1 (2.6%) Good: 11 (28.2%) Fair: 16 (41.0%) Poor: 8 (20.5%) Bad: 3 (7.7%)	Students were provided with three sites, 6 (18.2%) accessed at least one designated mathematical learning resource site.
	Cartesian Coordinates (3-D)	Over all students a total 12 different sites were chosen to examine the subtopic: 6 students (13.9%) used trusted sites while 37 students (86.1%) used untrusted sites.	Students' self ratings: Excellent: 0 (0.0%) Good: 14 (35.9%) Fair: 18 (46.2%) Poor: 7 (17.9%) Bad: 0 (0.0%)	Students were provided with three sites, 12 (36.4%) accessed at least one designated mathematical learning resource site.
	Polar Coordinates (3-D)	Over all students a total 12 different sites were chosen to examine the subtopic: 39 students (90.7%) used trusted sites while 22 students (78.8%) used untrusted sites.	Students' self ratings: Excellent: 1 (2.6%) Good: 10 (26.6%) Fair: 17 (43.6%) Poor: 10 (25.6%) Bad: 1 (2.6%)	Students were provided with three sites, 13 (39.4%) accessed at least one designated mathematical learning resource site.
	Graphics with parameters	Over all students chose a total 10 different sites to examine the subtopic: 39 students (90.7%) used trusted sites while 4 students (9.3%) used untrusted sites.	Students' self ratings: Excellent: 2 (5.1%) Good: 5 (12.8%) Fair: 15 (38.5%) Poor: 16 (42.0%) Bad: 1 (2.6%)	Students were provided with three sites, 7 (21.2%) accessed at least one designated mathematical learning resource site.

For guided hyperlearning, a comparison of the mean marks of students who accessed at least one website compared to the mean marks of students who did not access any sites showed no significant difference (t=1.356, df=31, p-value=0.185) in marks compared to those who did not access links. Again data regarding student

performance on the subtopics was not available to examine if there was a relationship between accessing a site and pre-test scores.

5.2.3.4 Use of trusted sites

It was expected that students in the guided hyperlearning group would use the electronic mapping system to access and use only lecturer/teacher' designated of trusted sites of the mathematical learning resources. For each of the three topics and for each subtopic the students were provided with three trusted sites, sites that were verified by lecturer. In unguided hyperlearning group, only 39.4 per cent of the total 575 hyperlinks to resources over all three topics were from trusted resources. One benefit for teachers is that these resources can be reviewed for later inclusion in electronic maps of mathematical learning resources for guided hyperlearning in the next year or the next semester of same or related courses.

The percentage of students from the guided and unguided hyperlearning groups accessing trusted learning sites for each topic is presented in Table 5.14. The highest percentage (79.5%) of students accessing trusted sites was achieved by the guided hyperlearning group for the number system topic and unguided hyperlearning for *Functions* (66.9%) and *Graphics* (90.7%).

Table 5.14. Comparing percentage of students accessing trusted websites in GH and UH

Topic: Number System

Method	1. History	2. Natural Number	3. Rational Number	4. Arithmetic Operation	5. Special Topics	Average
UH	21.2	36.3	27.2	27.2	39.4	30.3
GH	41.0	79.5	17.9	64.1	15.4	43.6

Topic: Functions

Method	1. Definition	2. Operation	3. Composition	4. Special Functions	5. Graphics of Functions	Average
UH	66.9	71.9	30.8	35.9	31.5	47.4
GH	20.9	16.3	14.0	9.3	7.0	13.5

Topic: *Graphing* **s**

Method	1. Cartesian Coordinates (2D)	2. Polar Coordinates (2D)	3. Cartesian Coordinates (3D)	4. Polar Coordinates (3D)	5. Graphics with Parameters	Average
UH	83.7	11.7	13.9	90.7	91.2	58.2
GH	63.6	18.2	36.4	39.4	21.2	35.8

5.2.3.5 Demographics and background variables

The dependent variable, students' academic performance, achieved through the implementation of guided hyperlearning, unguided hyperlearning, and conventional learning is measured through marks on pre- and post-tests. There is the possibility that these variables may impact differently for the three learning methods, that is they may exhibit an interaction.

The manner in which interactions were examined, involved comparing whether or not there was a difference in performance for each of the demographic and background variables for each learning method. An interaction would exist where a significant difference occurred for say one topic, but not another. This results in a total of 54 tests (18 tests for each topic), and requires the significance level to be adjusted (Pallant, 2010, p. 247) by the Bonferroni method $0.05 \div 54 \approx 0.001$. Thus, according to Table 5.15, no background variable significantly interacted with topics because all p-values values are higher than 0.001.

Table 5.15 Interactions between Participants' Demographic Components

No	Demographic Component	Topic: Number System		Topic: Functions		Topic: Graphing	
		F	Sig	F	Sig	F	Sig
Group A		Method: Conventional Learning		Method: Guided Hyperlearning		Method: Unguided Hyperlearning	
1	Age	0.629	0.679	0.776	0.573	1.549	0.199
2	Gender	6.235	0.017	0.085	0.772	0.219	0.642
3	Computer Skills	0.195	0.823	0.732	0.487	0.995	0.379
4	Type of Computer	2.014	0.128	0.889	0.455	0.968	0.418
5	Frequency of Internet Connection	1.908	0.144	0.213	0.887	0.474	0.702
6	English Skills	0.962	0.332	0.316	0.714	0.436	0.513
Group B		Method: Guided Hyperlearning		Method: Unguided Hyperlearning		Method: Conventional Learning	
1	Age	0.545	0.741	0.843	0.529	1.074	0.393
2	Gender	1.028	0.317	3.900	0.056	0.713	0.404
3	Computer Skills	4.230	0.047	0.373	0.545	0.000	0.986
4	Type of Computer	0.058	0.812	0.225	0.638	0.255	0.617
5	Frequency of Internet Connection	0.704	0.556	0.763	0.523	0.208	0.890
6	English Skills	0.028	0.869	0.032	0.859	0.021	0.885
Group C		Method: Unguided hyperlearning		Method: Conventional Learning		Method: Guided Hyperlearning	
1	Age	1.322	0.286	0.451	0.771	3.048	0.033
2	Gender	7.193	0.012	1.016	0.321	0.322	0.574
3	Computer Skills	0.351	0.707	1.741	0.193	1.681	0.203
4	Type of Computer	0.120	0.732	0.244	0.625	10.095	0.003
5	Frequency of Internet Connection	0.257	0.855	1.640	0.202	1.163	0.341
6	English Skills	2.275	0.120	0.047	0.954	0.800	0.459

5.2.3.6 Nature of differences in performance due to teaching method

To examine the impact of the teaching method changing is complicated. The process of the examination is as follows:

1) The first step involves gaining a sense of the design clarifying the means and standard deviations. The differences between performance scores (post-test minus pre-test) are revealed in the following table 5.16. At first glance results suggest that students' academic performance declined for all learning methods for the topics *Functions* and declined for the unguided hyperlearning group for the topic *Graphing*, however as discussed in section 5.1.2 the post-tests were harder (refer Table 5.3 and 5.4).

Table 5.16 Difference in mean performance scores (post-test minus pre-test)

	Number		Functions		Graphing	
	Mean	Sd	Mean	Sd	Mean	Sd
CL	0.74	1.47	-2.48	1.56	0.49	1.66
UH	0.91	1.44	-3.13	2.21	-1.35	1.90
GH	1.18	1.12	-2.67	2.13	0.54	2.56

Profile plots provides evidence of interactions and the nature of the interactions as revealed in Figure 5.2

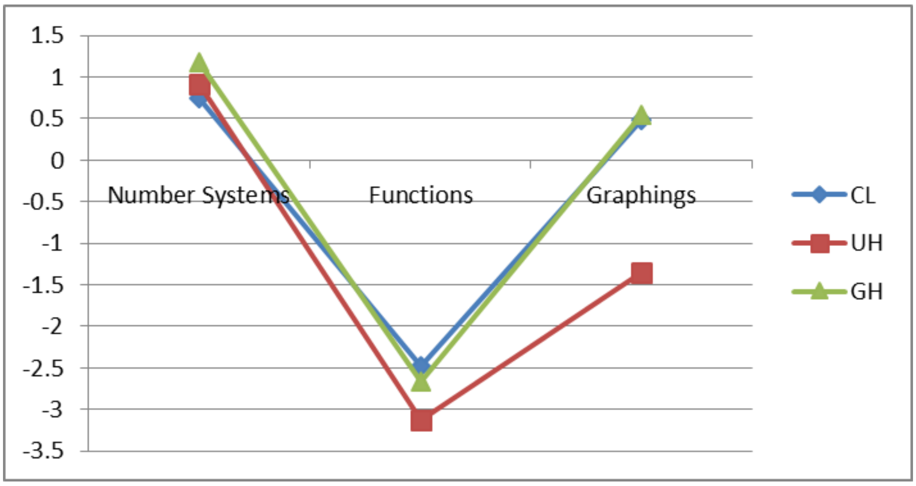


Figure 5.2 Profile plots of difference in performance scores

2) Dependent variables of this tests are students academic performance (difference of post minus pre-test mark) with independent variables are teaching methods (CL, GH, and UH)

   The assumptions of repeated measures ANOVA are similar to simple ANOVA, except that independence is not required and an assumption about the relations among the repeated measures (*sphericity*) is added (O'Connor, 2013). Using the repeated measures ANOVA following is results of assumptions checks

   a. Sample size, the number of cases in each cell (n=115) is more than dependent variables (n=3). Having a large sample help to ensure to avoid violations of the assumptions (such as normality).
   b. Normality, a sample size of more than 20 in each cell should ensure robustness (Pallant, 2010, p. 249). So with current sample size of n=115 in each cell the robustness of data for normality should be ensured.
   c. Outliers, by comparing the maximum value of Mahal. Distance (1.793) with critical value for evaluating Mahalanobis distance for three dependent variables (16.27, reference: Pallant, 2010, p. 251), it is indicative if there being no multivariate ouliers in this data because the Mahal. Distance value is less than the critical value (1.793 < 16.27).

Table 5.17 Result of Mahalanobis Distance Test
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.7653	.9366	.8435	.06953	115
Std. Predicted Value	-1.125	1.339	.000	1.000	115
Standard Error of Predicted Value	.126	.210	.174	.035	115
Adjusted Predicted Value	.6798	1.0101	.8437	.07461	115
Residual	-2.93657	4.23472	.00000	1.33978	115
Std. Residual	-2.182	3.147	.000	.996	115
Stud. Residual	-2.209	3.178	.000	1.005	115
Deleted Residual	-3.01008	4.32023	-.00022	1.36544	115
Stud. Deleted Residual	-2.249	3.316	.002	1.016	115
Mahal. Distance	.011	1.793	.991	.737	115
Cook's Distance	.000	.102	.010	.016	115
Centered Leverage Value	.000	.016	.009	.006	115

a. Dependent Variable: diff1

d. Homogenity of variance-covariance matrix, result of Box's test (F=2.388, sig = 0.004) revealed that this assumption is not violated because the sig value (0.004) is larger than 0.001.
e. Equality of variance, result of Levene's test (refer table 5.18) revealed that this assumption is not violated because no sig value is less than 0.05.

Table 5.18 Result of Levenes's test of equality of error variances

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
diff of pre and post-test phase I	.927	2	112	.399
diff of pre and post-test phase II	1.624	2	112	.202
diff of pre and post-test phase III	2.928	2	112	.058

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

f. Sphericity, the Mauchly's test of sphericity, indicated that the assumption of sphericity (that the error covariance matrix of the normalised transformed dependent variables is proportional to an identity matrix) is not violated (χ^2 =2.57, *df*=2, p<.0.277) (refer Table 5.19).

Table 5.19 Results of Mauchly's Test of Sphericity[b]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
treatment	.978	2.566	2	.277	.978	.995	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Within Subjects Design: treatment

A repeated Measures ANOVA with three performance scores (pre-test-post-test) for the topics, *Numbers*, *Functions* and *Graphing* as dependent variables and teaching methods as the independent variable suggests there is an interaction ($F_{(2,112)}$=127.64, p<.0005).

Table 5.20 Results of test of within-subjects effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Topic	Sphericity Assumed	799.374	2	399.687	127.638	0.000
	Greenhouse-Geisser	799.374	1.956	408.662	127.638	0.000
	Huynh-Feldt	799.374	1.990	401.730	127.638	0.000
	Lower-bound	799.374	1.000	799.374	127.638	0.000
Error (topic)	Sphericity Assumed	713.959	228	3.131		
	Greenhouse-Geisser	713.959	222.992	3.202		
	Huynh-Feldt	713.959	226.841	3.147		
	Lower-bound	713.959	114.000	6.263		

Given there was an interaction further analyses are required to determine the nature of the differences in performance given different topics and learning methods Subsequent analyses involved the examination of univariate ANOVA's.

b) Followup analyses ANOVAs

Results of the analysis revealed no significant differences in mean performance scores between the three learning groups for the topic *Number Systems* ($F_{(2,112)=}0.186$, $p<0.830$), and no significant difference in mean performance scores between the three learning groups for the topic *Functions* ($F_{(2,112)=}0.992$, $p<0.374$). For the topic *Graphing*, the conventional group and the guided hyperlearning group performed better than the unguided hyperlearning group ($F_{(2,112)=}8.260$, $p<0.000$).

Table 5.21 ANOVA Table between learning groups and topics of learning

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
diff1	Between Groups	.680	2	.340	.186	.830
	Within Groups	204.503	112	1.826		
	Total	205.183	114			
diff2	Between Groups	8.078	2	4.039	.992	.374
	Within Groups	456.043	112	4.072		
	Total	464.122	114			
diff3	Between Groups	93.472	2	46.736	8.260	.000
	Within Groups	633.693	112	5.658		
	Total	727.165	114			

Post hoc Bonferroni comparisons revealed that the GH and CL groups had better performance than the UH (refer Table 5.22).

Table 5.22 Post hoc Analysis in Regard to Methods Implemented in Topic Graphing

Multiple Comparisons: Bonferroni

(I) treatment_topic3	(J) treatment_topic3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
UH	CL	-1.83602*	.52598	.002	-3.1144	-.5576
	GH	-1.89429*	.55049	.002	-3.2322	-.5564

*. The mean difference is significant at the 0.05 level.

These results suggest that there is essentially no difference in the learning outcomes from the three learning methods except for topic dominated by psychomotor skills, *Graphing*. For this topic there was a difference in performance between the three learning groups. Unguided hyperlearning was less satisfactory that the other methods for the graphing topic.

An exploration of sites suggests that learning resources in the internet, predominantly provide knowledge for users to be read, and are far less likely to be used to train users to do something to increase their psychomotor skills. For the topic areas chosen it would appear that the current resources on the internet are more appropriate for the development of cognitive skills than they are for the development of psychomotor skills. Through the implementation of guided hyperlearning, educators can direct students to the most appropriate resources or selected web sites that can help them to support learning whose learning objectives are psychomotor skills. This finding suggests that the development of web resources accessible via the internet and appropriate for people to develop skills related to physical manipulation is required.

5.2.3.7 Participants satisfaction and evaluation

Implementation of guided hyperlearning and unguided hyperlearning provide participants with a different learning experience to learning through conventional or traditional learning methods. This experience was evaluated comparing measures on five point rating scales measuring with the categories *Very Satisfied* to *Not Satisfied*. Measures of satisfaction were obtained for each of the five variables:

1. Access to mathematical learning resources during the learning method
2. Quality of mathematical learning resources provided or found during the learning process
3. Design of learning process when using unguided hyperlearning and guided hyperlearning
4. Interaction between lecturer and students during the learning process
5. Benefit of the learning methods applied

A five point scale ranging from *Strongly Agree* to *Strongly Disagree* was used to evaluate the learning experience.The evaluation components comprised:

1. Ease of access mathematical learning resources
2. No difficulty, that is whether there were any problems in accessing or using the mathematical learning resources.
3. Support for participants' self-learning
4. Support for participants' ability to learn anywhere and anytime
5. Appropiate to the students current ICT acess whether at home or school

Mean rankings for the satisfaction and evaluation components for guided hyperlearning, unguided hyperlearning, and conventional learning are presented in Tables 5.23 and 5.24. Comparison of these participants' rankings was conducted using a Friedman two-way analysis of variance test. This is a non-parametric test used with ranked data to determine if the mean ranks of three or more related samples or groups differ significantly (Cramer and Howitt, 2004, p. 68). In this case, this test was used to compare students' satisfaction with and evaluation of GH, UH, and CL. Because in total there are 30 multiple tests (ten tests, namely five satisfaction measures and five evaluation measures for each topic) then the significance level needs to be adjusted (Pallant, 2010, p. 247) becomes $0.05 \div 30 \approx 0.002$. With respect to students' evaluation results as revealed in Table 5.23, only the evaluation component *no difficulty* which is consistently rated by three groups as significantly different between CL, GH, and UH. CL is likely to be easier to follow by students, as indicated by higher score of mean rank for all groups A, B, and C.

Table 5.23 Friedman test of evaluation components

No	Aspect	Group A (all topics)				Group B (all topics)				Group C (all topics)			
Evaluation Components													
		Mean Rank			Sig	Mean Rank			Sig	Mean Rank			Sig
		CL	GH	UH		CL	GH	UH		CL	GH	UH	
1	Easy to access mathematical learning resources	**2.51**	**1.81**	**1.67**	**0.000**	2.28	1.77	1.95	0.011	**2.42**	**1.65**	**1.92**	**0.000**
2	No difficulty	**2.43**	**1.79**	**1.78**	**0.000**	**2.37**	**1.76**	**1.87**	**0.000**	**2.42**	**1.48**	**2.09**	**0.000**
3	Supporting participants self-learning	2.07	1.93	2.00	0.638	1.91	2.00	2.09	0.526	1.82	2.12	2.06	0.155
4	Supporting participants to learn anywhere & anytime	1.91	2.06	2.03	0.529	**1.47**	**2.26**	**2.27**	**0.000**	1.79	2.17	2.05	0.052
5	Appropriate to Current ICT Condition	1.93	2.15	1.92	0.154	**1.63**	**2.14**	**2.23**	**0.000**	1.77	2.15	2.08	0.057

Table 5.24 Friedman test of satisfaction components

No	Aspect	Group A (all topics)				Group B (all topics)				Group C (all topics)			
Satisfaction Components													
		Mean Rank			Sig	Mean Rank			Sig	Mean Rank			Sig
		CL	GH	UH		CL	GH	UH		CL	GH	UH	
1	Access to Mathematical Learning Resources	**2.52**	**1.80**	**1.67**	**0.000**	**2.42**	**1.59**	**1.99**	**0.000**	2.30	1.82	1.88	0.032
2	Quality of Mathematical Learning Resources	**2.56**	**1.91**	**1.53**	**0.000**	2.31	1.90	1.79	0.013	2.32	1.74	1.94	0.003
3	Design of Learning	**2.38**	**1.78**	**1.84**	**0.000**	2.28	1.79	1.92	0.006	**2.32**	**1.77**	**1.91**	**0.001**
4	Interaction Between Lecturer and Participants	**2.45**	**1.70**	**1.85**	**0.000**	**2.53**	**1.64**	**1.83**	**0.000**	2.32	1.91	1.77	0.015
5	Beneficial	**2.40**	**1.80**	**1.80**	**0.000**	2.28	1.81	1.91	0.006	2.15	1.89	1.95	0.256

With respect to students' satisfaction results as revealed in Table 5.24, there are significant differences in students mean satisfaction ranks for all measures of satisfaction when comparing the CL, GH, and UH for Group A students, with the mean rank of CL higher for each satisfaction component than GH and UH. For Group B students, only the components *access to mathematical learning resources* and *interaction between lecturer and participants.*

Although guided hyperlearning and conventional learning provide the same academic performance for cognitive, psychomotor, and combination of cognitive and psychomotor skills, students' satisfaction ratings and evaluation ratings suggest they prefer and found it *easier to follow* Conventional Learning (CL) than Guided Hyperlearning (GH) in mathematics. With respect to Unguided Hyperlearning (UH), which is associated with lower academic performance for the topic involving, psychomotor skills, *Graphing*, UH is less preferred compared to Conventional Learning for Group A students.

5.2.4 Conclusion

Teachers can be reasonably comfortable in providing students with a variety of learning experiences in mathematics. Students with guidance are able to access sites independently rather than passively responding to conventional learning techniques. Using guided hyperlearning students can gain much needed experience with technology, without there being a decline in mathematics skills. There is however a caution in relation to using hyperlearning where there are heavy demands on psychomotor skills.

In learning mathematics, students prefer conventional learning methods rather than guided hyperlearning although these two methods resulted the same academic results for the topics involving cognitive, psychomotor and combination of these aspects. If the desired outcomes include independent learning rather than a passive style of learning then guided hyperlearning has something to offer. Conventional learning also has limitations whereby the lecturer and students need to be in the same class at the same time. So, in some circumstance, in which conventional learning cannot be

conducted for one or more reasons or the lecturer would like to achieve a larger audience or the audiences are to come from different places and cannot join together in one room for conventional learning, then guided hyperlearning is a suitable replacement for conventional learning in terms of achieving the same academic results. There may also be situations such where students have chosen distance learning where guided hyperlearning may be advantageous.

5.3 Mapping curriculum (Indonesian context)

In the implementation study in Bojonegara Sub District, Indonesia (refer Section 4.3) teachers experimented with the mapping of resources and learning designs. The learning design maps represent a map of part of the curriculum. Curriculum mapping may be thought of as the entirety of maps for each aspect contained with a curriculum. According to Kallick and Colosimo (2009, pp. 2-10) curriculum mapping is important in order to create a vision, and to provide data for further improvements. In this section the use of electronic mapping tools to map curriculum is explored through 1) examination of teachers' opinions and 2) the theoretical combining of maps of several parts of the Indonesian curriculum.

5.3.1 Examination of teachers opinions

In the implementation case studies involving 13 teachers, discussion as to how the electronic maps, created by teachers could be linked and aligned to the formal Indonesian curriculum document were undertaken. Teachers rated the use of LDMaps in the relation to curriculum mapping (refer Table 5.25). As revealed by Table 5.25, all teachers agreed that, in regard to curriculum, an electronic mapping system is of benefit in terms of supporting curriculum, documenting resources and learning designs, and all saw that these maps could be synchronized to map the national curriculum. Electronic maps (GRMap and LDMap) could be aligned by the relevant government departments to the formal curriculum and supplied to teachers.

It was also seen that the tools could support teachers' creativity in developing teaching resources and allow them to arrange versions of the curriculum.

When it came to teachers' ability to create and modify electronic maps in regard to curriculum and whether teachers would like to share electronic maps all but one teacher agreed that these were desirable outcomes.

Table 5.25 Teachers' evaluation of the tools in regard to curriculum

No	Aspects	Evaluation					
		Strongly Agree		Agree		Neutral to Strongly Disagree	
		Count	%	Count	%	Count	%
1	Relation to Curriculum						
	a) Supporting Curriculum	8	61.5	5	38.5	0	0.0
	b) Documenting Resources and Learning Designs	5	38.5	8	61.5	0.0	0.0
	c) Synchronize to National Curriculum	5	38.5	8	61.5	0.0	0.0
	d) Support teachers creativity on developing teaching resources	5	38.5	8	61.5	0.0	0.0
	e) Teachers could arrange their own mathematics curriculum	4	30.8	9	69.2	0	0.0
	f) Teachers 'ability to create and modify electronic maps in regard to curriculum	3	23.1	9	69.2	1	7.7
	g) Teachers would like to share electronic maps	3	23.1	9	69.2	1	7.7

5.3.2 Mapping the Indonesian Curriculum

The latest version of Indonesian national curriculum, at the time of this research, is *Dokumen Kurikulum 2013* (Curriculum Document year 2013) by the Ministry of National Education and Culture, Republic of Indonesia. The National curriculum in elementary schools is implemented through thematic teaching and learning, so the mathematics content is mixed with other subjects such as Indonesian language and writing. On the other hand, the mathematics curriculum in senior high school is predominantly for preparation of students to take tertiary study at university or college levels. For that reasons, as illustrated by Figure 5.2, a sample of the national curriculum for junior high schools is selected to illustrate how mapping using LDMap and GRMap for the purposes of curriculum review is undertaken.

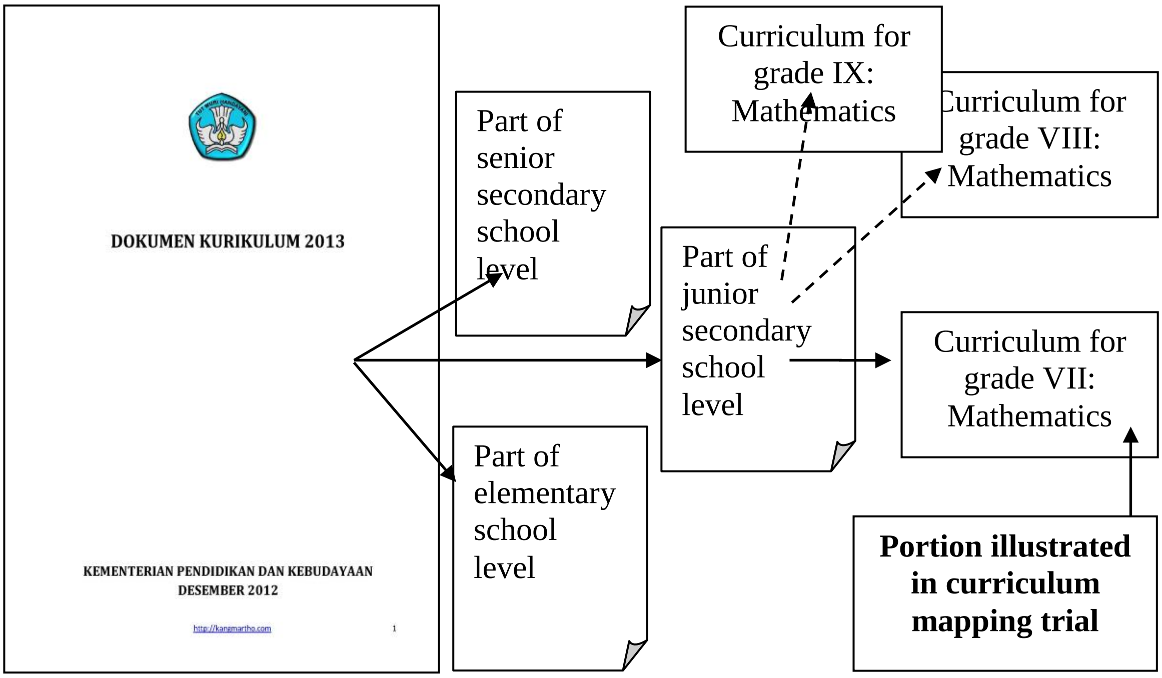


Figure 5.3 Selection of competencies to be mapped using LDMap and GRMap

In total, the national curriculum for junior secondary school is comprised of ten subjects. In this section, researcher selected the mathematics curriculum of grade VII for the purposes of demonstrating the mapping of a curriculum.

Table 5.26 List of subjects of Indonesian curriculum document year 2013 for junior secondary schools

SUBJECT		**Hours of study/ week**		
		Grade VII	**Grade VIII**	**Grade IX**
Group A				
1.	Moral and Religion	3	3	3
2.	State philosophy (Pancasila) and civic education	3	3	3
3.	Indonesian language	6	6	6
4.	Mathematics	5	5	5
5.	Science	5	5	5
6.	Social Science	4	4	4
7.	English	4	4	4
Group B				
1.	Art and Culture	3	3	3
2.	Sport	3	3	3
3.	Creative work	2	2	2
Total hours per week		**38**	**38**	**38**

As displayed in Table 5.62, for each basic competency, one appropriate LDMap and one GRMap can be provided to document learning designs and resources accessible via the internet for these competencies. Mapping of learning designs for these basic competencies can preserve the documentation of teaching practice, from written document to modifiable and shareable map. These electronic maps can be circulated among teacher to know how other conducting teaching and learning for this competency.

Table 5.27 Selected basic competency and its associate LDMap and GRMap

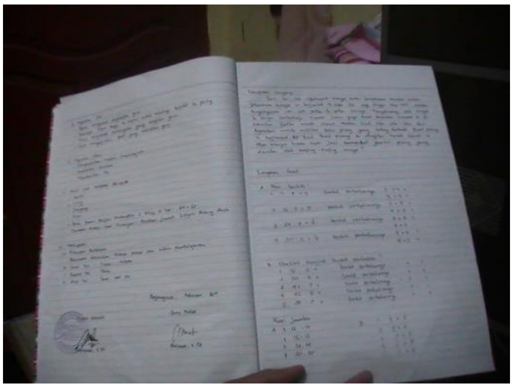
No	Basic Competency	Link of electronic maps	
		LDMap	GRMap
1	Comparing various type of numbers and conducting arithmetic operation for natural numbers and fractions	LDMap_JSS_VII_3_1	GRMap_JSS_VII_3_1
2	Understanding set, subset, complement of set, and its operation, and provide an example and not example of these terms	LDMap_JSS_VII_3_2	GRMap_JSS_VII_3_2
3	Calculating value of variable in one variable linear equation systems	LDMap_JSS_VII_3_3	GRMap_JSS_VII_3_3

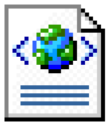
Note: JCC: Junior Secondary School.

To facilitate a curriculum review the name of file can be structured in system as following:

[type-eMap]_[school-level]_[grade]_[main-competency-no]_[basic-competency-no]

For example: "LDMaP_JSS_VII_3_1" represents the LDMap for junior secondary school level, grade VII, main competency number 3 and basic competency number 1. As proposed in the curriculum review section (section 5.4), these maps as they are based on XML technology can be transferred inter-platform and operating system, collected and imported by head of institutions to undertake a review of the total curriculum (or for sharing of maps).





Written document of teaching practice   Learning Designs Map (LDMap)

Figure 5.4 From written document to digital file

Further exploration and implementation by teachers as distinct from the researcher is required to know the practical implications of this technique demonstrating what is required for a curriculum review in higher education (see section 5.4).

5.4 Curriculum review

There are fundamental differences between people's conceptions of curriculum, focusing on curriculum as reality in teaching and learning in the class and curriculum as a plan for or a report of actual educational events (Posner, 2004, p. 5). Posner (2004, p. 5) also stated that some people claim that a curriculum is the content, standards, or objectives for which schools hold students accountable, while the other claim that a curriculum is the set of instructional strategies teachers plan to use. Further, Kallick and Colomo (2009, p. 4) proposed that there are often differences between the written curriculum and the taught curriculum. In addition, Kelly (2009) also discussed that the term curriculum is used with several meanings, and a number of different definitions of it have been offered. Kelly (2009, p 7-13) suggested people to recognize five types of curriculum as explained below.

1) The educational curriculum

The focus will be not just on how one might plan any kind of curriculum, but on what it is that will ensure that the curriculum is justifiable in educational terms.

2) The total curriculum

According to the Department of Education and Science/Welsh Office (1981), in Kelly (2009, p. 9), schools should plan their curriculum as a whole. The curriculum offered by a school, and the curriculum received by individual pupils, should not be simply a collection of separate subjects. In addition, Kelly (2009, p. 9) stated that the very least, the total curriculum must be accorded prior consideration.

3) The hidden curriculum

Curriculum may include implicit values in the arrangement made by schools for their pupils.

4) The planned curriculum and the received curriculum

There is a distinction between the official curriculum and the actual curriculum, or the planned curriculum and the received curriculum. The official or planned curriculum indicates what is laid down in syllabuses, prospectus, and so on, while the actual or received curriculum is the reality of the pupils' experience.

5) The formal curriculum and the informal curriculum

There is a distinction often drawn between formal activities for which the timetables of the school allocates specific periods of teaching time and those

informal activities that are often called extracurricular activities. The first activities are included in the formal curriculum, and the latter is separated in the informal curriculum.

In this thesis, curriculum is defined as the list of subjects, comprising a formal course of study that states the resource and the design of learning in order to achieve the purpose of curriculum stated by an institution. This perspective of the written curriculum is chosen because the research deals with the written curriculum documents or the teaching that is expected. In addition to this definition, by regarding the total curriculum, the design of curriculum must be defined by a school or college in which the curriculum will be implemented.

Curriculum needs to be reviewed or evaluated to make it appropriate given current conditions and the development of the institution, as also explained by the seminal paper by Dressel (1965) about the importance of curriculum review. According to Davis (1981) there are 11 types and purposes related to curriculum review. One type of review relevant to this research is that of institutional self-study. Davis (1981) in his book *Teachers as Curriculum Evaluators* also emphasize that teachers are the main participants in the review or evaluation of curriculum. Based on this view, teachers or the persons who conduct teaching and learning of subjects formally listed in the curriculum, should be empowered to participate in the process of curriculum review.

As the target group for this work expanded to encompass both schools and universities the term educator is used to refer to school teachers and/or university lecturers, while the term unit refers to an educational institution or department which uses or develops their own curriculum, such as a school or department. The process of curriculum review in this thesis in focused on the mathematics discipline, but could be extended to other disciplines.

Curriculum mapping as the way to implement curriculum review is conducted based on a vision for the school or university. A responsible educator for the course maps

the resources and learning designs for each formal subject, resulting in a set of files. These maps contain data regarding expectations of what is to be taught, in their class. Additional technology tools to draw together the individual learning design maps to provide an overall mapping of the curriculum in terms of content or competencies required and the development of this is discussed in the next section.

5.4.1 Developing Curriculum Review Capabilities

The purpose of curriculum review tools developed to use Learning Design Maps (LDMap) was to improve the usability of the electronic mapping system though extending its use, allowing the use of collected data/maps of learning designs to accomplish another educationally useful function, the curriculum review. By taking advantage of LDMaps' characteristics and ability to document learning designs data such as the assessment tasks set and the graduate attributes, the learning design data of each subject can be aggregated and displayed for review purposes.

A series of activities were undertaken to identify:

1) What was required of a curriculum review in one specific instance, a partial curriculum review of a mathematics degree at the University of Wollongong (UOW), Australia;
2) Examination of existing review software in terms of functionality;
3) Extension of the LDSoft mapping tools through development of additional curriculum review tools to enable the use of LDMaps in curriculum review; and
4) Interviews with staff at the UOW to assess their needs in relation to curriculum mapping.

These activities were conducted at the University of Wollongong, Australia, a developed country, with a view to gathering information for future direction on how this tool could be implemented in developing countries. Developed countries have IT infrastructure and facilities, manpower, money, and legal obligations that are seemingly not available in developing countries (refer Figure 5.4). For that reason in

practice, the sophistication and integration of curriculum review tools possible in developed countries cannot be implemented in developing countries that do not have provision of the substantial IT support that is required. However the fundamentals of curriculum review which can be applied in developing countries can be identified, and in this case the extension of functionality of the learning design maps is implemented to facilitate curriculum review in developing countries.

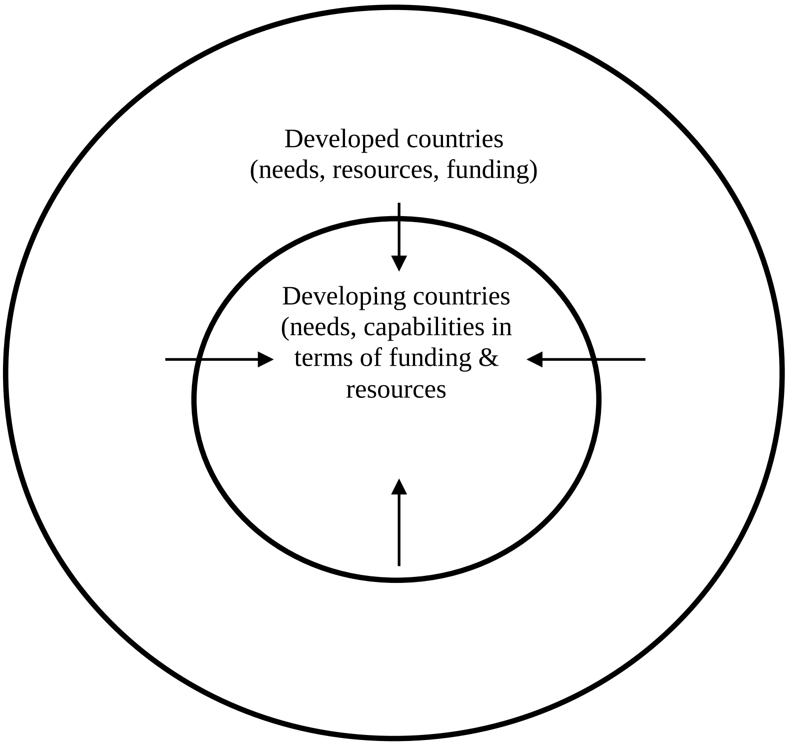


Figure 5.5 Curriculum review tools: developing and developed nation

5.4.1.1 Mathematics curriculum review, University of Wollongong (UOW)

The Bachelor of Mathematics degree curriculum at University of Wollongong (UOW) consists of 30 subjects that spread throughout four subject levels of 100-level, 200-level, 300-level, and 400-level. Each level has different course requirements and difficulty for completion. The subjects consist of 6 (20%) of 100-level courses, 8 (26.7%) of 200-level courses, 14 (46.7%) of 300-level courses, and 2 (6.7%) of 400-level courses. A complete list of subject is provided in Table 5.23 (from the UOW Handbook of Courses, year 2013, and available at: http://www.uow.edu.au/handbook/index.html).

Table 5.28 List of subjects for Bachelor of Mathematics Program

No	Subjects		Session	Credit Points
	Mathematics Related Subjects: 100-Level			
1	MATH187	Mathematics 1: Algebra and Differential Calculus	Autumn	6
2	MATH188	Mathematics 2: Series and Integral Calculus	Spring	6
3	MATH111	Applied Mathematical Modeling 1	Spring	6
4	MATH121	Discrete Mathematics	Spring	6
5	STAT131	Understanding Variation and Uncertainty	Autumn	6
	Mathematics Related Subjects: 200-Level			
6	MATH201	Multivariate and Vector Calculus	Autumn	6
7	MATH202	Differential Equations 2	Spring	6
8	MATH203	Linear Algebra	Autumn	6
90	MATH204	Complex Variables and Group Theory	Spring	6
10	MATH212	Applied Mathematical Modeling 2	Spring	6
11	MATH222	Continuous Mathematics	Autumn	6
12	STAT231	Probability and Random Variables	Autumn	6
13	STAT232	Estimation and Hypothesis Testing	Spring	6
	Mathematics Related Subjects: 300-Level			
14	MATH302	Differential Equations 3	Autumn	6
15	MATH305	Partial Differential Equations	Spring	6
16	MATH312	Applied Mathematical Modelling 3	Autumn	6
17	MATH317	Financial Calculus	Autumn	6
18	MATH321	Numerical Analysis	Spring	6
19	MATH322	Algebra	Autumn	6
20	MATH323	Topology and Chaos	Spring	6
21	MATH371	Special Topics in Industrial and Applied Mathematics 3	Spring	6
22	STAT304	Applied Probability and Financial Risk	Autumn	6
23	STAT332	Linear & Generalized Linear Models	Spring	6
24	STAT333	Statistical Inference	Spring	6
25	STAT335	Sample Surveys and Experimental Design	Autumn	6
26	STAT373	Special Topics in Probability and Statistics 3	Spring	6
27	STAT374	Special Topics in Applied Statistics 3	Spring	6
	Informatics Related Subjects			
28	CSCI114	Procedural Programming	Autumn/Spring	6
29	INFO411	Data Mining and Knowledge Discovery	Autumn	6
30	INFO412	Mathematics for Cryptography	Autumn	6

To complete the study for a Bachelor of Mathematics degree, a student is required to satisfactorily complete at least 144 credit points which must include eight core subjects: 1) MATH187, 2) MATH188, 3) MATH111 or MATH212, 4) MATH121 or MATH222, 5) STAT131 or STAT231, 6) CSCI114, 7) MATH201, MATH202, MATH203 or MATH204, 8) MATH212, MATH222, or STAT231. A schematic of the Bachelor of Mathematics degree is revealed in Figure 5.6.

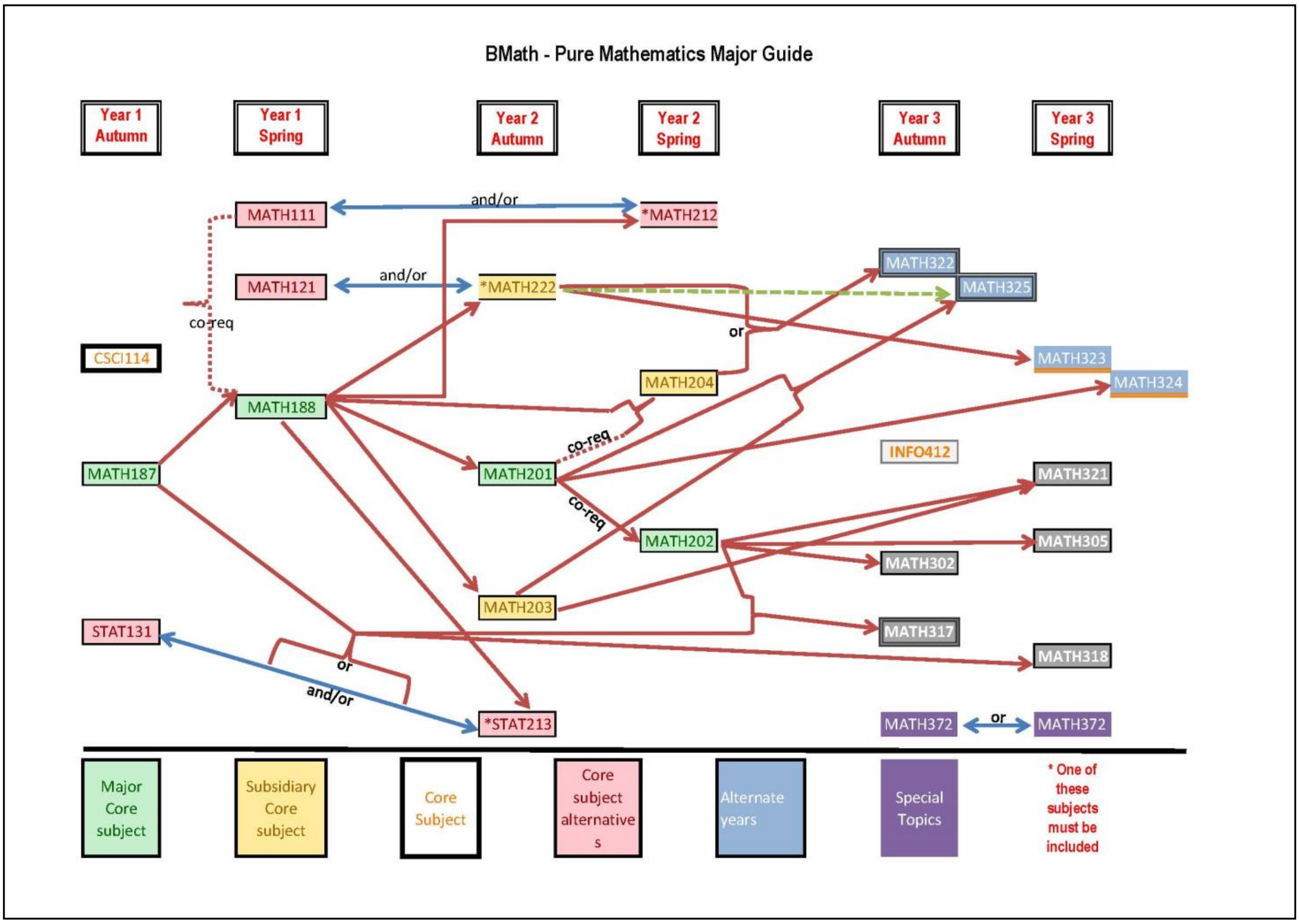


Figure 5.6 Bachelor of Mathematics schematic (School of Mathematics and Applied Statistics, UOW, 2013).

The partial curriculum review of mathematics at the UOW for demonstration purposes is based on an analysis of two subjects, rather than the entire set of mathematics subjects using the curriculum mapping tools developed. The review in part adopts the critical steps in the evaluation process as described by Davis (1981, p. 50). The activities included examination of the need for a learning design based curriculum review.

5.4.1.2 Need for a learning design based curriculum review

The need for a curriculum review must be identified in order to conduct an appropriate review. In the case of the University of Wollongong, at a meeting of the University of Wollongong Education Committee in 14 November 2012 provided a resolution outlining the vision related to curriculum mapping as follows:

> *Recommendation regarding methods of curriculum mapping: [we need to] invest in a system that is relevant for staff and students, meet the information requirements of external bodies, contributes to our capacity to better evaluate students learning, and makes better use of our human resources, making the process of curriculum mapping automatic, scalable, and sustainable.*
>
> (University Education Committee Report, 2012, p. 51)

Frustration with the retrospective process, mapping of curriculum after teaching or course development had transpired was articulated along with the limited resources to accomplish the task. A variety of software tools were discussed.

> *Results indicate [we] need to rethink [the] approach [to curriculum review] with retrospective mapping proving problematic. Engineering, Graduate School of Medicine, and Commerce have used their own method to map and the Curtin mapping tool has been used in some areas. However without resources by Faculties, it is difficult to progress further.*
>
> (University Education Committee Report, 2012, p. 51)

Curriculum mapping in at the UOW context relates to the importance of ensuring graduate attributes or qualities or other terminology as institutions use are obtained by students by graduation. In terms of a curriculum review of mathematics at the UOW, the University is committed to developing graduates with qualities that will equip students for roles in society and the workplace Following is the list of UOW Graduate Qualities as listed in UOW Web Site:

1. *INFORMED*
   New graduates are not expected to 'know everything', but they are expected to have begun to have become discerning regarding the sources of knowledge they rely on.

2. *INDEPENDENT LEARNERS*
   New graduates know that they are beginners in the area in which they have been employed. The new graduate is expected has an accurate sense of what they know and what they do not know.

3. *PROBLEMS SOLVERS*
   New graduates in their career path, involves finding solutions to problems. Each discipline has different types of problems to solve and different ways of finding solutions. Being a good problem solver requires students to develop their creativity, confidence, teamwork skills and capacity for persistence.

4. *EFFECTIVE COMMUNICATORS*
   New Graduates need to be effective communicators for a number of reasons. Communication skills are required to understand the nature of the puzzles and problems new graduates need to solve as part of their everyday work.

5. *RESPONSIBLE*
   New graduates need to be safe and feel that it is worthwhile to contribute to a community or a workplace people consider that it is important that they are valued as human beings and they are included and treated with respect.

(University of Wollongong, 2012)

These qualities are further defined at the Faculty and School level. In this case, based on the UOW Graduate Qualities, the School of Mathematics and Applied Statistics (SMAS, 2012) interpreted these qualities as follows:

1. *INFORMED*
   a. *Have sound technical knowledge in mathematics at a level to enable informed contribution in the community*
   b. *Understand the applications of mathematics to other fields.*
   c. *Be aware of the breadth of the discipline(s) of mathematics and/or statistics.*

2. *INDEPENDENT LEARNERS*
   a. *Have skills in accessing, understanding, summarising, extending and generalizing technical information*
   b. *Have the ability to work independently.*
   c. *Be able to demonstrate a facility with technical computer software that enhances their expertise in mathematics.*
   d. *Understand conventions for the referencing, citation and attribution of the work of others.*

3. *PROBLEM SOLVERS*
   a. *Be capable of applying logical, analytic and creative thinking to a range of problems.*

b. Display skills in constructing clear, precise and rigorous mathematical arguments as well as critical thought and analysis in the practice of mathematics.
c. Are able to identify and apply relevant mathematical techniques to a problem; adapting or extending them as necessary.

4. EFFECTIVE COMMUNICATORS
a. Be able to communicate effectively on mathematical issues at technical and lay level and in both oral and written form.
b. Be able to interpret data and results from mathematical analysis and draw valid conclusions.
c. Have the ability to work collaboratively in teams as professionals.

5. RESPONSIBLE
Be aware of and able to develop arguments about limitations and ethical and privacy issues, in the design, analysis and written reports of mathematical and/or statistical models and studies.

(School of Mathematics and Applied Statistics, 2012)

The existence of curriculum blueprints would allow the institution to conduct audits of current programs, research the best materials and curricula, and to support research-based approaches to teaching and learning. Blueprints also incorporate the analysis of students' assessment data for the purpose of informing curricula (Reusche, 2008). Students can use blueprints as a concise record of their educational program content, while faculty can use blueprints as a measure of quality assurance, and in particular, at the time of curriculum and course revisions a redistribution of teaching responsibilities (Fullerton, and Pickwell, 2007, p. 66).

In the absence of a blueprint that determines what these topics and processes are, this review and the associated development of curriculum mapping tools draws on the graduate qualities, such as being informed and this is inclusive of content and processes used by mathematicians. The review relies on the topics as covered by the mathematics subjects.

The list of graduate qualities is a vision that the School of Mathematics and Applied statistics wants to be achieved by implementing its current curriculum. The data gathered thorough this curriculum mapping using the technology developed is based

on subjects taught by lecturers. This mapping can then be compared with the vision, or the main goal of the institutions.

5.4.1.3 Software for curriculum review

To use the LDMaps of subjects for the purposes of curriculum review two tasks were undertaken:

1) A review of the literature regarding curriculum mapping and relevant tools and their effectiveness for curriculum review; and
2) Modification of LDMap and design and development of the LDForm (Learning Design Form) and LDCR (Learning Design-based Curriculum Reviewer) so that they could accommodate the needs of curriculum review

As the literature reveals, curriculum mapping is facilitated by software or computer applications that can help the educators to aggregate data then provide a summary of the data in terms that are required, and in this case have been collected in the individual subject mappings. While highly valued by some for example, the University of Wollongong, many people consider the practice of curriculum mapping as a labor-intensive, data-entry exercise, widely regarded as costly to many and valuable to few (Sumsion and Goodfellow, 2004, in Oliver et al, 2010, p.81).

One of the major impediments even in developed nations is that curriculum mapping can be costly, in terms of tools and time. Without naming the commercial software, the cost of a commercial curriculum mapping software service was recently posted as in the vicinity of $US8500 per year. (Williams, 2012, p. 22),

> *“The mapping work that's been done does have some value, but that value came at an enormous cost, and I'm not sure I see us having the political will to keep the project well-maintained into the future”*
>
> (a Moodle forum member, https://moodle.org/mod/forum/)

According to a Moodle forum member (https://moodle.org/mod/forum/), many users of one package used for curriculum review, Atlas, ceased use when needing to upgrade to newer versions. Atlas has a high cost to implement, including the upgrades from one version to newer versions. However in same forum, some users also stated that Atlas is useful and has good staff support. Costs are of course relative, but if there are problems in developed countries then the issue of cost will be magnified in developing countries.

In regard to effective practice with curriculum review software, Oliver et al, (2010), stated that three considerations have emerged:

> *Three major considerations for effective practice emerge from the literature: (1) the tool—an instrument, document or package which allows aggregation of a course; (2) a process—the way in which the tool is used with and by teaching and support staff; and (3) the purpose for which curriculum mapping is adopted.*
>
> (Oliver, Ferns, Whelan, and Lilly, 2010, p. 80)

These three considerations can be further elaborated:

1) Development of standards or common core components. Standards can be in relation to matters such as naming conventions for files, the composition of categories in each field depend on the organization's needs.

> *My impression is that if a number of schools were to team together we could fund development and provide it to the moodle community as open-source. Standards etc could be formatted/entered by those interested in those standards, and downloaded/installed ready to import by anyone.*
>
> (a Moodle forum member https://moodle.org/mod/forum/)

The development of standards also will enable better collaboration and communication between lecturers/teachers, in particular to assist them in communication of the content (resources), skills, and assessments used in their classroom (Koppang, 2004, p. 154).

The development of standards is not straight forward, with the process of key concern. The active participation of teachers in curriculum mapping is promoted.

> *The idea is not a tool that 'standardises everything, but allows teachers to effectively map out how they plan to deliver a course - and you are right. some teachers might use it to map it out in a manner that is not how you would... it doesn't mean the tool is a bad idea*?
>
> (a Moodle forum member https://moodle.org/mod/forum/)

2) The process or procedure for how curriculum mapping is conducted. The complexity of the process or procedure depends on the tool used and level of educational institutions where curriculum mapping is conducted. The practice of curriculum review is expected to enable automatic and easy update of the curriculum mapping for review. Technology is considered as important for use in this process (Delgaty, 2009, p. 36)

3) The purposes relate to institutional needs and identification of the content. This activity is for tracking or mapping purposes and it is also expected to provide benefit for program evaluation and accreditation (Perlin, 2011, p. 28), for example, review is often concerned with content, skills, assessments, and lessons and in the case of UOW graduate attributes. Further curriculum review or mapping is in response to society’s expectation for greater accountability in higher education (Britton, Letassy, Medina, and Er, 2008, p. 2) so people will be know the expected quality or qualities of graduates.

4) Effective practice to aggregate the course data for use by teaching, support staff, and institutions. It is also considered that teachers need to see something that makes their efforts easier, not more difficult.

> *Teachers spent hours creating curriculum binders [for use in curriculum review] that were rarely used because they cannot be updated easily (Williams, 2012, p. 22).*

> Literature critiques also identified functions lacking in tools. Some of these are appropriate in developed nations where funding and IT support is available for example the development of web-based application that is required a high performance of IT infrastructure and facilities (Oliver, Fern, Whelan, Lilly, 2010; Lai, Wood, and Marrone, 2012).

Many curriculum mapping software tools have been developed in order to facilitate educators conducting curriculum mapping. Examples of such software are presented in Table 5.29. It was found that scientific articles that discuss this specific software is rare. For developing countries the primary limitations of these are that many of the software tools require institutional ICT infrastructure and facilities, and many of the software tools have high cost commercial products or services. Two of these tools, the Excel based Curtin tool was used to undertake a review of the mathematics curriculum at UOW, while the Faculty of Commerce tool was designed for the specific conditions of the Commerce faculty. Staff interviews (Section 5.4.1.5) in relation to these tools identified a number of limitations or needed future developments. The Curtin tool applied in the School of Mathematics and Applied Statistics was for example limited in terms of its flexibility and modifiability as it was primarily designed to meet the needs of another institution.

Table 5.29 List of Curriculum Review/Mapping Software

No	Name of Software	Developer(s)	License	Feature(s)	Review
1	Rubicon Atlas Curriculum Mapping	Rubicon International	Commercial	Able to organize, communicate, and disseminate information as the solution to managing curriculum and sharing instructional best practices across grades, subjects, schools, and cultures. Personnel Support. Supported with the most current and enhanced curriculum data.	Atlas is a Web application designed to electronically encompass the process of curriculum mapping to facilitate collaboration among teachers across subjects, grades and schools. Atlas probably the first and well-known educational software focused in curriculum mapping. Rubicon, the owner of Atlas provides training to teachers on how to use and implement this software. According to its users, Atlas is easy to use, useful, productive mapping software, and has a good and helpful technical support. Many schools and educators already become its users for years. Atlas also considered as time-consuming and frustrating for many, in part because it is divorced from the courses it maps.
2	Agile Minds Curriculum Mapping and Design	Australian Curriculum Consultant	Commercial	Able to design and map curriculum. Familiarity with Australian curriculum.	The curriculum mapping tool is provided by an Australian curriculum consultant who has expertise in mapping Australian curriculum. This software is not so popular like Rubicon Atlas
3	Excel-based Curriculum Review	Curtin University	Private ownership	Able to analyse course data automatically by typing or pasting data to the excel cell provided in this tool.	This is a research based curriculum mapping tool. This tool is currently well-known in Australia. This software has limited capability in terms of modification.
4	Curriculum Mapping Tools	Faculty of Commerce UOW	Private ownership	Web-based curriculum mapping. Integrated information about graduate qualities. Data and information can be exported to excel files to be analyzed later.	This software is being been developed and is currently being trialed in the Faculty of Commerce, UOW. This software is web-based software.

5	TODCM Curriculum Mapping	Tiller Software Company	Open Source	Web-based Curriculum Mapping Software. Customizable. Real time PDF generation	TODCM is a software framework that helps schools and organizations to implement a curriculum mapping tool according to their own specific requirements. TODCM already implemented in four international schools: TODCM is based on the user interface concept of the Zurich Mapping System (ZMS) developed by Greg Curtis, Zurich International School. TODCM is claimed to be has feature like commercial software.
6	Curriculum Mapper	Collaborative Learning, Inc	Commercial	Simple interface to align curriculum, share best practices, and create a variety of custom reports for both administrators and teachers	The Curriculum Mapper is a web-based mapping system developed by classroom teachers and administrators. It allows teachers to easily input curricular data as well as attach lesson plans, rubrics, to any part of their maps
7	TechPaths	Performance Pathways	Commercial	Search and share features provided to enhance collaborations among teachers when developing maps.	A Curriculum Mapping System. Data entry of curriculum map elements contains essential questions, content, skills, assessments, and lessons. The information entered by teachers provides numerous reports to aid administrators in understanding the curriculum as implemented by teachers in their schools and District as they attempt to align to standards.
8	CurricuPLAN	Seacliff Education Solution	Commercial	Web based curriculum mapping. Provides online access for educators to participate in an online community.	CurriculPLAN is a web based curriculum mapping and instructional content management solution that provides online access for educators to participate in an online community focused on the development of high quality instruction with the common goal of increasing student achievement.
9	Moodle		Open source Some aspects are commercial.	Additional capability of course management system for use in curriculum mapping.	Moodle is originally purposed as a Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE), however curriculum mapping features are implemented through a Moodle platform as this helps provide a (potentially) integrated tool to allow planning/ mapping of HOW to teach content, that is learning design.

The ability to adapt the LDMaps for the purposes of curriculum review was based on the ability for the learning design data in the LDMaps to be captured and reused and connected to other applications. One proposed use with this data is mathematics curriculum review as illustrated in Figure 5.6. In mapping the curriculum, one needs to identify the core subjects that all students must complete in order to complete a given degree. At the UOW core subjects need to encompass all learning outcomes or graduate attributes that are required, as there is no guarantee that all students complete the elective subjects. In the Bachelor of Mathematics at the University of Wollongong students must complete eight mathematics core subjects and this is complemented with a required choice of another elective mathematics (MATH or INFO code) subjects.

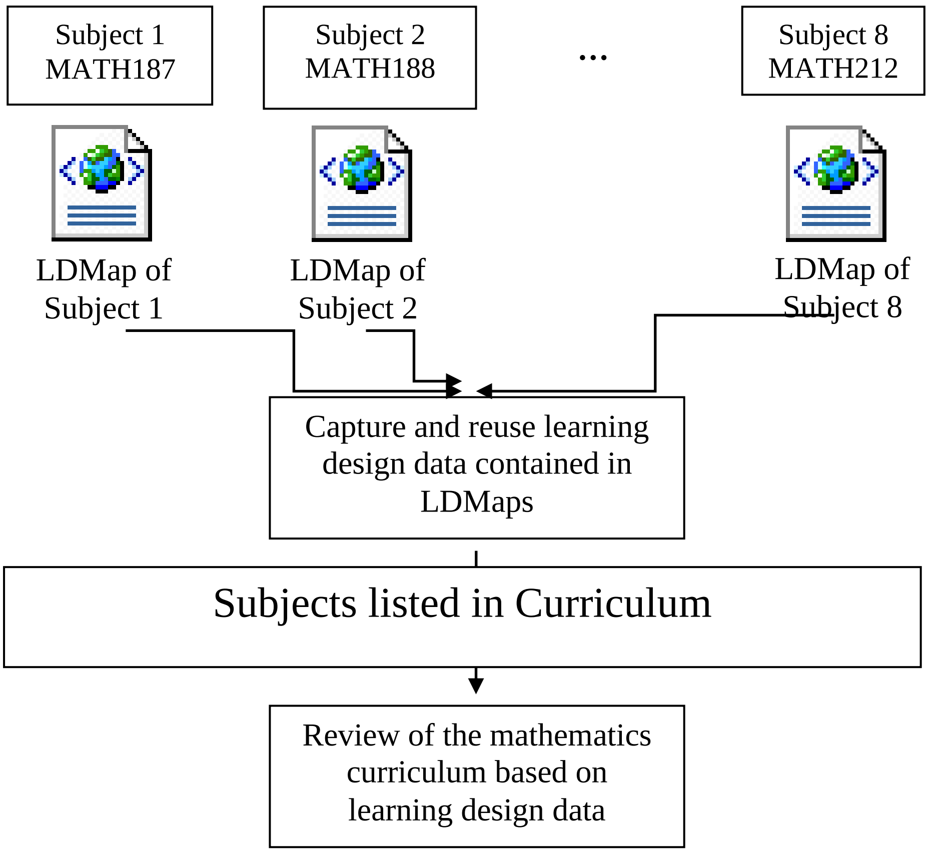


Figure 5.7 Integrating LDMap in Curriculum Review

Curriculum review is a long process. Typically the people responsible for these activities are one or two people (coordinators) who are responsible for this and it can be burdensome. Participations of lecturers in the review process by documenting their learning design in LDMaps, can disperse the process allowing the responsible coordinators or staff to easily and automatically conduct just the simple task of collating available LDMaps the review. Assuming, and this is not currently the case, that LDMaps were created for each core subject in the Bachelor of Mathematics degree, then there would be at least eight LDMaps available in the unit. Decisions would need to be made in relation to whether or not to include all alternative core subjects. The mathematics curriculum can be reviewed based on data contained in LDMaps associated with subjects in this degree. To ensure that data are available for aggregation prospectively, the data needs to be captured prospectively through existing processes, such as in the case of the UOW, compulsorily completed *Subject Information Sheets*.

To undertake a review of mathematics subjects at the University of Wollongong two main needs were identified and this required the collection of additional data to that collected in the earlier localised study, regarding:

1) Graduate qualities that were to be aligned with the tasks or assessment of the subject per week.

2) *Mathematics Subject Classifications* (MSC), a unique feature of mathematics in which mathematics-related literature can be indexed by topic, and subsequently aligned with mathematical learning resources provided in the subject each week.

The *Mathematics Subject Classification* is produced by editorial staff of *Mathematical Reviews* and *Zentralblatt fur Mathematik* (Zbl) in consultation with mathematical community. The list consists of 63 first level classifications started from 00: General to 97: Mathematics Education. A second level of classification is also available. This classification can be used to get a specific or detail information about the subtopics. The use of the second level, at this time

this remains to be developed and when implemented will be result in a second list of classifications to be selected in conjunction with the main topic selected by lecturers completing the LDForm.

3) Other needs (such as change field name of lecture to name of teacher) were also identified, however these were relatively simple changes compared to the important changes specified in 1) & 2).

To facilitate curriculum review, the original LDMap needed to be modified as described to satisfy the need of mathematics curriculum review at University of Wollongong. To accommodate these changes several nodes' names were added to accommodate for example graduate qualities and, MSC topic (See figure 5.7).

Original Code

```
<?xml version="1.0"?>
<!--LDSoft-->
<!--Contains Learning Design-->
<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>
```

Modified Code for Curriculum Review

```
<?xml version="1.0"?>
<!--LDSoft-->
<!--Contains Learning Design-->
<LDSoft>
  <Session>
    <Title> </Title>
    <Lecturer> </ Lecturer >
    <Week> </ Week >
    <Duration> </ Duration >
    <Resource> </ Resource >
    <MSC_Topic> </ MSC_Topic>
    <Type_Task> </ Type_Task >
    <Contribution_Mark> </ Contribution_Mark >
    <Process_Learning> </ Process_Learning >
    <Consultation> </Consultation>
    <Graduate_Quality> </ Graduate_Quality >
    <Note> </Note>
  </Session>
</LDSoft>
```

Figure 5.8 Original and modified code for the LDMap template

The modifications were to improve the usability of LDMap by adding fields that addressed the needs of the institution. The fact that the learning design maps needed to be modified to extend the use to the additional task of curriculum review

highlighted the need to enhance documentation regarding the development and modification of electronic mapping system in general (refer Section 5.6). To make the LDMaps more usable in curriculum review, the modification of the LDForm and LDCR is addressed in Section 5.4.3. A third modification as identified in the minutes of the UOW Education committee, was to overcome retrospective mapping, a problem as this places pressure on resources, after the teaching has taken place. To facilitate prospective data collection the LDForm page 1 (refer Figure 5.9) and page 2 (refer Figure 5.10) was redesigned to include information that is required in the compulsory *Subject Information Sheet* to be completed for each subject, each session at UOW and completed by the subject co-ordinator.

The data, when available, will be automatically update from one form to other forms. As can be seen through Figure 5.8, there is a flow of data (including learning design data) from the frontpage section to the remaining sections, which finally results in a LDMap. The lecturer or subject co-ordinator is required to complete the first (frontpage form) and the second/third page of the form (first/second half-semester form). The data in collected in these forms can then be used to generate the basic information in the *Subject Information Sheet* that can then be modified or added to if required by the lecturer. At the same time the data entered in the first three pages of the form 1) Front page form, 2) First half-semester form, and 3) Second half-semester form) is simultaneously added to a subject review form. This subject review form may then be exported to create a LDMap of the subject.

.

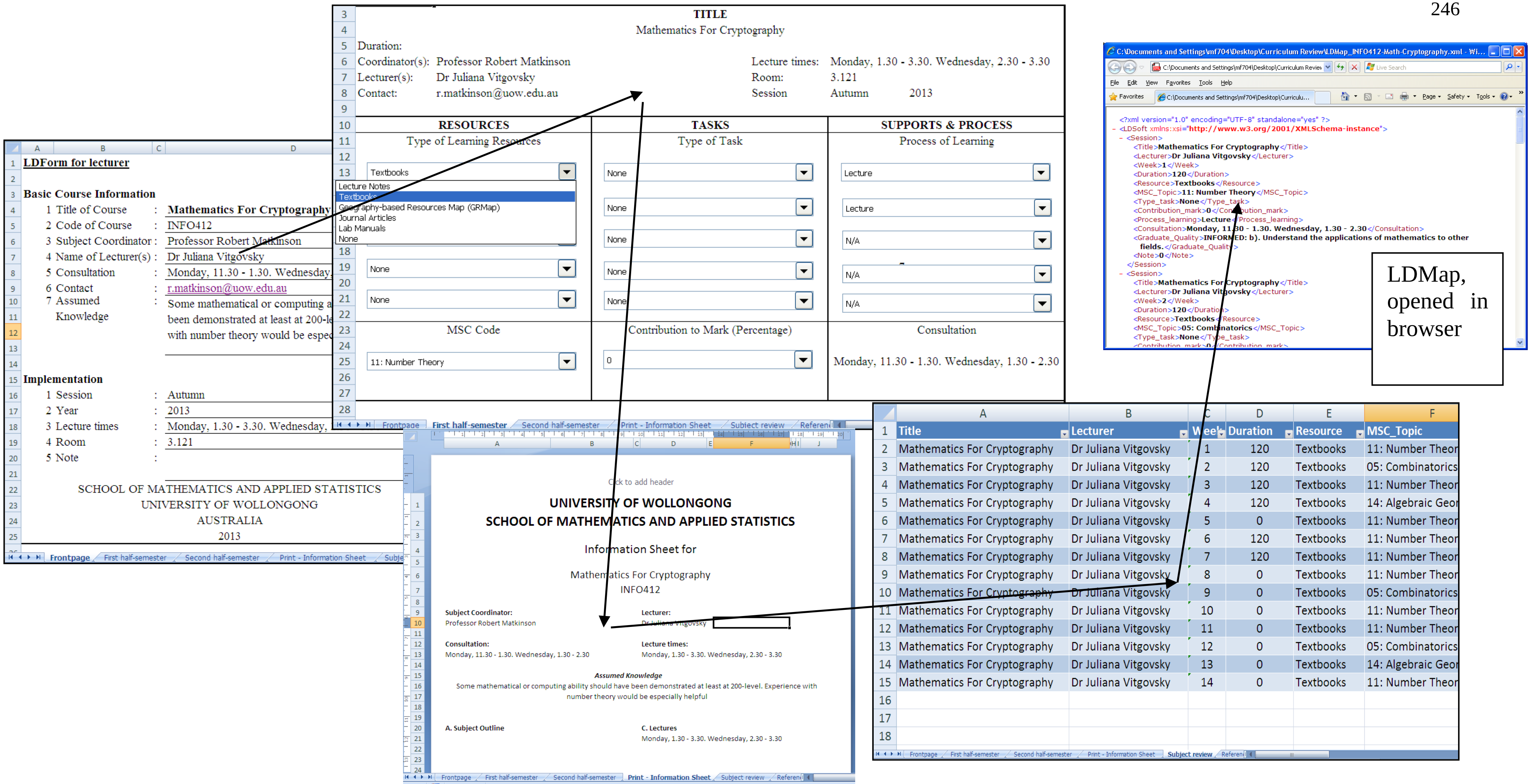
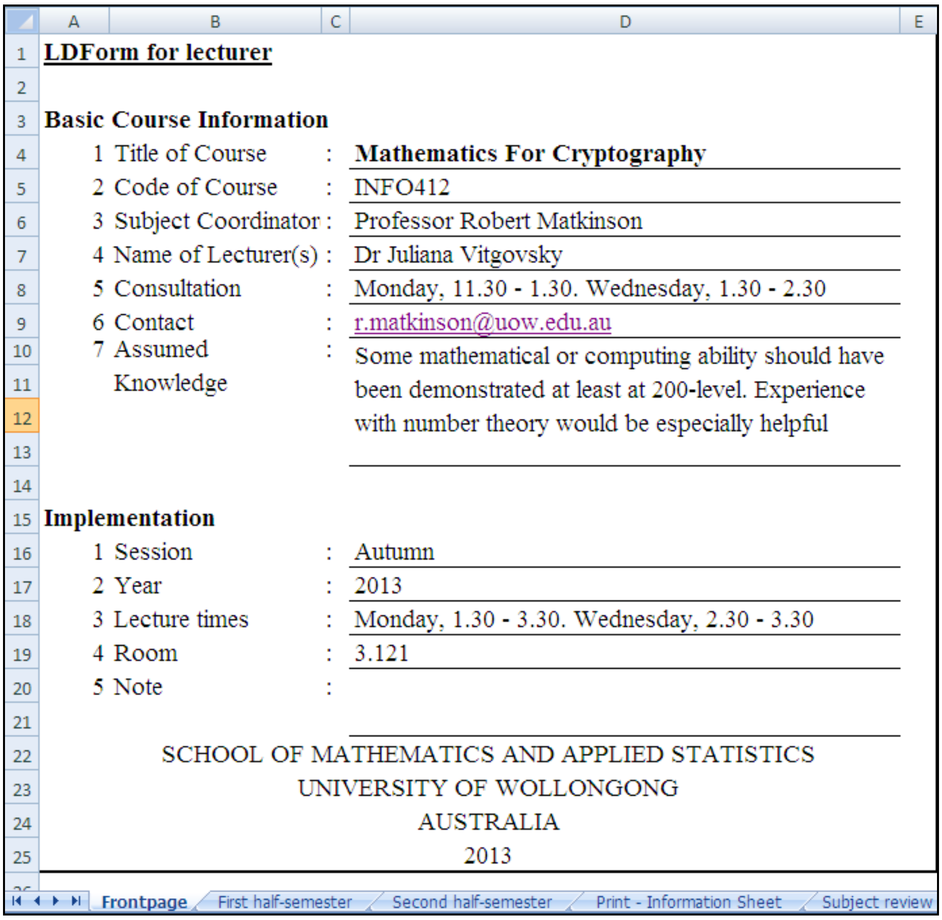


Figure 5.9 Automatic data flow from the frontpage section to subject review section to produce LDMap

In Indonesia, teachers are required to write a lesson plan, a working procedure to organise teaching and learning activities one or more basic competencies as listed in syllabi (Jakarta Education Office, 2013). In the school system for developing countries in general, including in Indonesia, the intended site of use, aligning the design of the form with that of lesson plans, which are compulsory in some education systems, would also serve to make data collection prospective rather than retrospective. For an effective curriculum review all core subjects need to be mapped and hence collection of data from some form of compulsory task such as a *Subject Information Sheet* or lesson plan is needed, but it also represents a shift away from voluntary completion and sharing to compulsory completion and from retrospective to prospective completion.



LDForm for lecturer

Basic Course Information

1	Title of Course	:	**Mathematics For Cryptography**
2	Code of Course	:	INFO412
3	Subject Coordinator	:	Professor Robert Matkinson
4	Name of Lecturer(s)	:	Dr Juliana Vitgovsky
5	Consultation	:	Monday, 11.30 - 1.30. Wednesday, 1.30 - 2.30
6	Contact	:	r.matkinson@uow.edu.au
7	Assumed Knowledge	:	Some mathematical or computing ability should have been demonstrated at least at 200-level. Experience with number theory would be especially helpful

Implementation

1	Session	:	Autumn
2	Year	:	2013
3	Lecture times	:	Monday, 1.30 - 3.30. Wednesday, 2.30 - 3.30
4	Room	:	3.121
5	Note	:	

SCHOOL OF MATHEMATICS AND APPLIED STATISTICS
UNIVERSITY OF WOLLONGONG
AUSTRALIA
2013

Frontpage | First half-semester | Second half-semester | Print - Information Sheet | Subject review

Figure 5.10 Learning Design Form (LDForm) page 1– Home

The home section is the *Frontpage* of LDForm and this is used to collect general information about the subject. Other sections are learning design data form for first half-semester and second half-semester (see Figure 5.10), which would be considered desirable in *Subject Information Sheets* section (see Figure 5.11) although not yet required, *Subject Review* section (see Figure 5.12), and list of data references (for use in modification of LDForm, refer section 5.4.3).

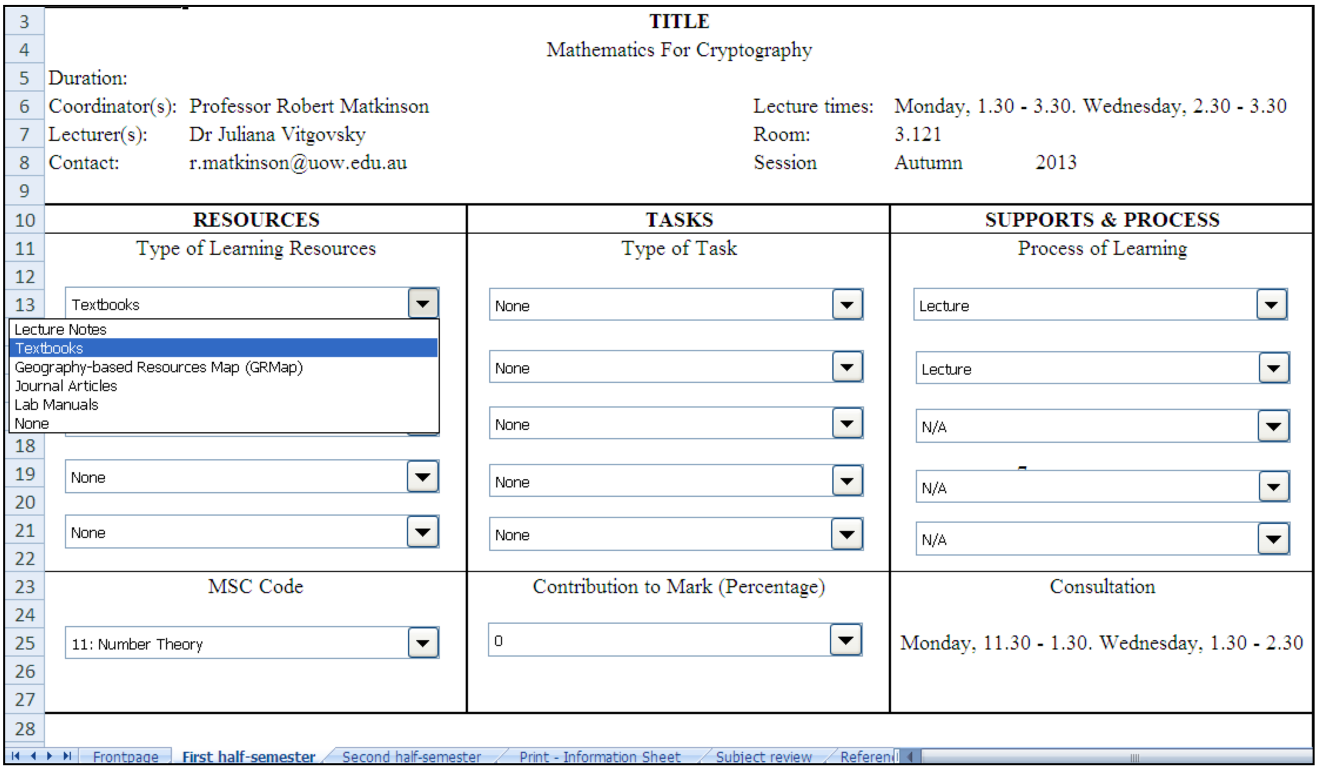


Figure 5.11 LDForm page 2 – Capturing Learning Design Data

The structure of LDForm and LDMap can be maintained by institutions and adapted to meet their needs. The information fields of the learning design include *Resources* (type or resources option: Lecture Notes, GRMap, Journal article, Lab manuals) with its associated MSC code, *Task* (type of task: Quiz, Individual task, Homework, Project, Mid Exam, and Final Exam) with its associated contribution (percentage) to mark, and *Support & Process* (process of learning: Lecture, Discussion, Workshop, Presentation, Blended learning, and Hyperlearning) in the LDForm and LDMap (listed in section References). These information fields are modifiable. Contents of

the drop down options, and new fields can be added as essential features of modifiability (See section 5.4.1.6). Change needs to be taken with care so that the forms over all subjects remain the same otherwise changes can lead to unexpected errors for institutions. The ability to change is necessary as different institutions may have different curriculum visions.

The learning design form can now be used to gather information that is provided in the *Subject Information Sheet* given to students at the commencement of each subject at the UOW. Data not traditionally provided in subject information sheets, but included in the LDforms includes aligned resources, tasks, and supports and the process of learning for each meeting or lecture. In this way the form as originally intended for the sharing of learning designs gathers data regarding the way the lecturer teaches student about a particular subject. The learning design in this way is "recorded" and is also available for the curriculum review.

The process for completion of the LDMaps is essentially the same as that outlined in the first set of studies. For the first phase, the LDForm is used to capture the expanded set of data, formerly collected in MS Excel file that is then exported to form a LDMap for use in curriculum review. The steps:

1) Fill in the required information at section *Frontpage*

2) Update the data of learning design for each meeting in section *First half-semester* and *Second half-semester*. Up to five resources can be documented for a week .

3) Modify and print the *Subject Information Sheet*, if needed. The template of the *Subject Information Sheet* will be produced, and this has the essential data such as name of subjects, lecturers, from the *Frontpage* of the LDForm. Lecturers can further modify the information sheet to satisfy their needs.

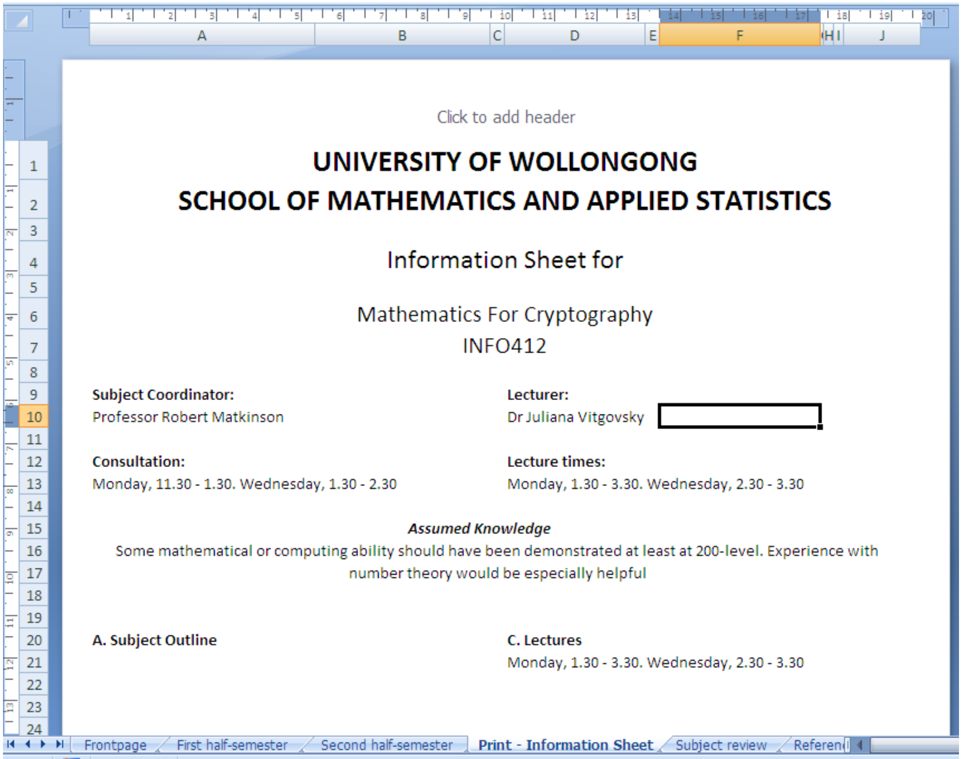
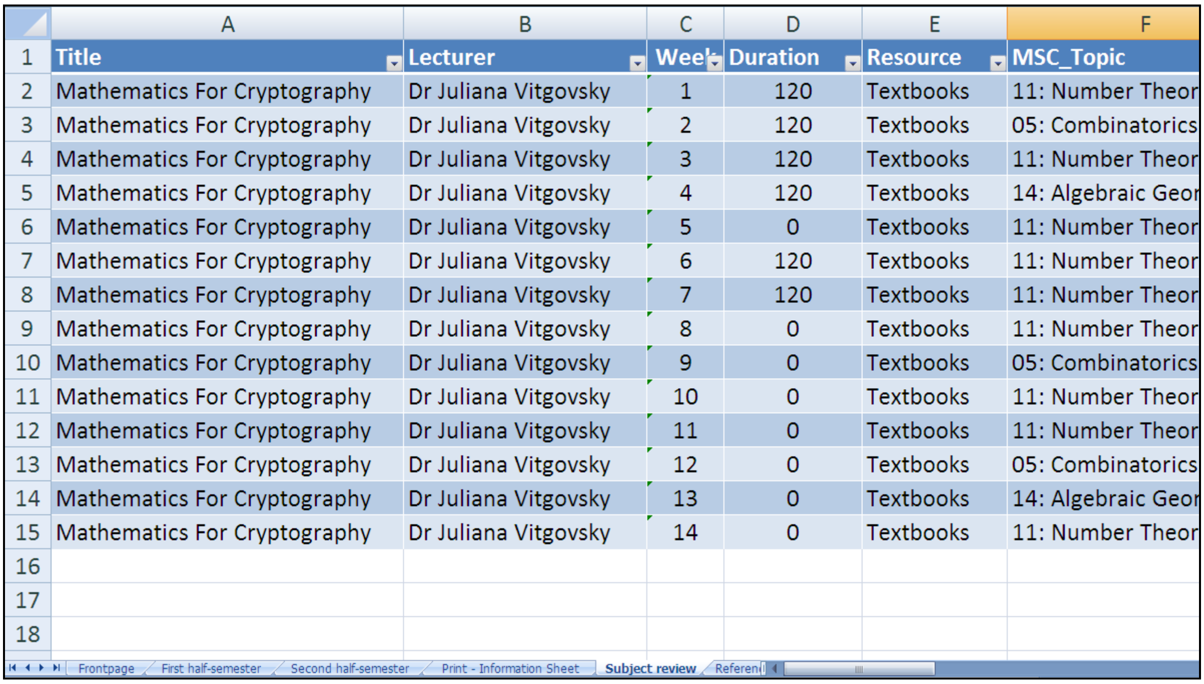


Figure 5.12 Print Preview of the Subject Information Sheet

4) Export the LDMap file. During the process of completing the LDForm, data is automatically updated in the section *Subject review* (See Figure 5.12). Data is then exported through *click export* to create the LDMap. In terms of desirable standards, files should be exported so as the LDMap file has the subject code as



	A	B	C	D	E	F
1	Title	Lecturer	Week	Duration	Resource	MSC_Topic
2	Mathematics For Cryptography	Dr Juliana Vitgovsky	1	120	Textbooks	11: Number Theor
3	Mathematics For Cryptography	Dr Juliana Vitgovsky	2	120	Textbooks	05: Combinatorics
4	Mathematics For Cryptography	Dr Juliana Vitgovsky	3	120	Textbooks	11: Number Theor
5	Mathematics For Cryptography	Dr Juliana Vitgovsky	4	120	Textbooks	14: Algebraic Geor
6	Mathematics For Cryptography	Dr Juliana Vitgovsky	5	0	Textbooks	11: Number Theor
7	Mathematics For Cryptography	Dr Juliana Vitgovsky	6	120	Textbooks	11: Number Theor
8	Mathematics For Cryptography	Dr Juliana Vitgovsky	7	120	Textbooks	11: Number Theor
9	Mathematics For Cryptography	Dr Juliana Vitgovsky	8	0	Textbooks	11: Number Theor
10	Mathematics For Cryptography	Dr Juliana Vitgovsky	9	0	Textbooks	05: Combinatorics
11	Mathematics For Cryptography	Dr Juliana Vitgovsky	10	0	Textbooks	11: Number Theor
12	Mathematics For Cryptography	Dr Juliana Vitgovsky	11	0	Textbooks	11: Number Theor
13	Mathematics For Cryptography	Dr Juliana Vitgovsky	12	0	Textbooks	05: Combinatorics
14	Mathematics For Cryptography	Dr Juliana Vitgovsky	13	0	Textbooks	14: Algebraic Geor
15	Mathematics For Cryptography	Dr Juliana Vitgovsky	14	0	Textbooks	11: Number Theor
16						
17						
18						

Frontpage / First half-semester / Second half-semester / Print - Information Sheet / Subject review / Referen

Figure 5.13 Raw Data Section of LDForm

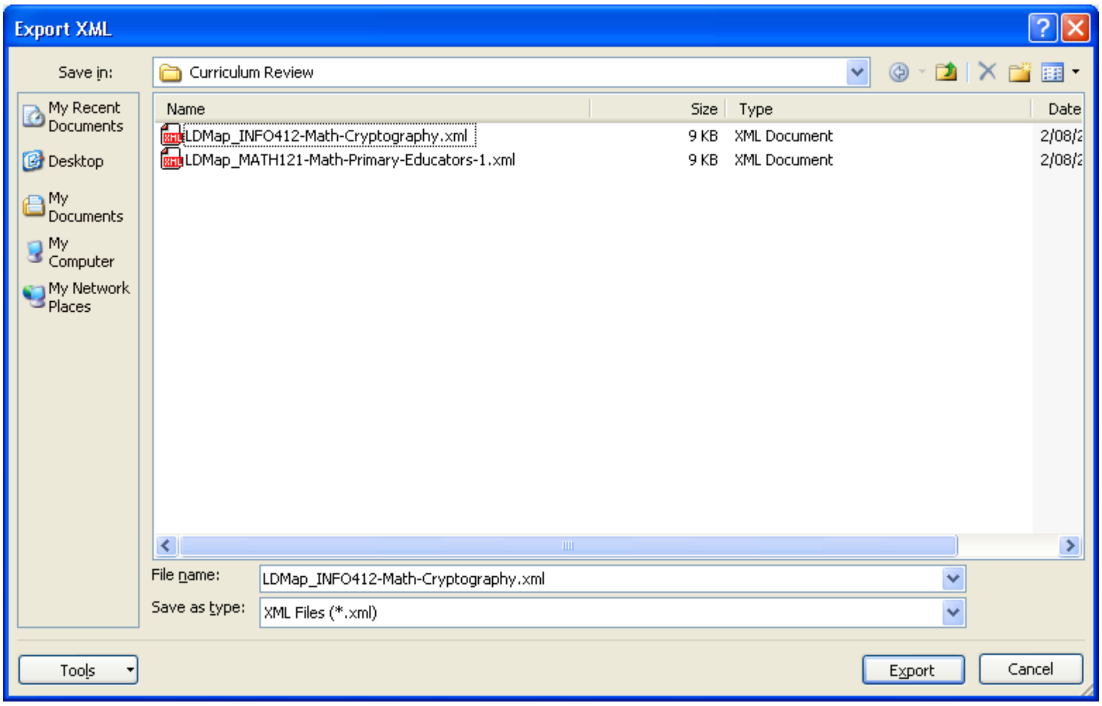


Figure 5.14 Exporting Learning Design Data to LDMap

5.4.1.4 Analysis of LDMaps in a curriculum review

To analyze the data contained in LDMaps (refer Figure 5.14), an additional tool to automatically analyse these maps, Curriculum Reviewer, was required. Like the LDForm, this tool was designed and developed based in Microsoft Excel. Curriculum Reviewer can be used to import the data from all LDMaps of the required subjects for use in the curriculum review. The analysis of the data contained in these files can be done automatically. To demonstrate, a curriculum review is conducted as a simulation of a review of mathematics curriculum of the School of Mathematics and Applied Statistics, University of Wollongong, New South Wales, Australia. A review of all subjects could be used for self-reflection on the current mathematics curriculum or to document for external accreditation bodies that the graduate attributes were met.

Demonstrations of the use of the curriculum tools will be based on two selected mathematics subjects from the School of Mathematics and Applied Statistics, University of Wollongong. *Discrete Mathematics* (MATH121) and *Mathematics for Primary Educators* (MATH131) were selected as the example for this purpose. This partial review will focus on the process for reviewing: 1) Subject information; 2) Mathematical learning resources; 3) Topics taught as classified with the *Mathematics Subjects Classification*; 4) Distribution of expected graduate qualities; and 5) Subjects' assessments.

The step by step or scenario of the use of LDMap for curriculum review follows:

1) Open the LDCR (Microsoft Excel based tool)

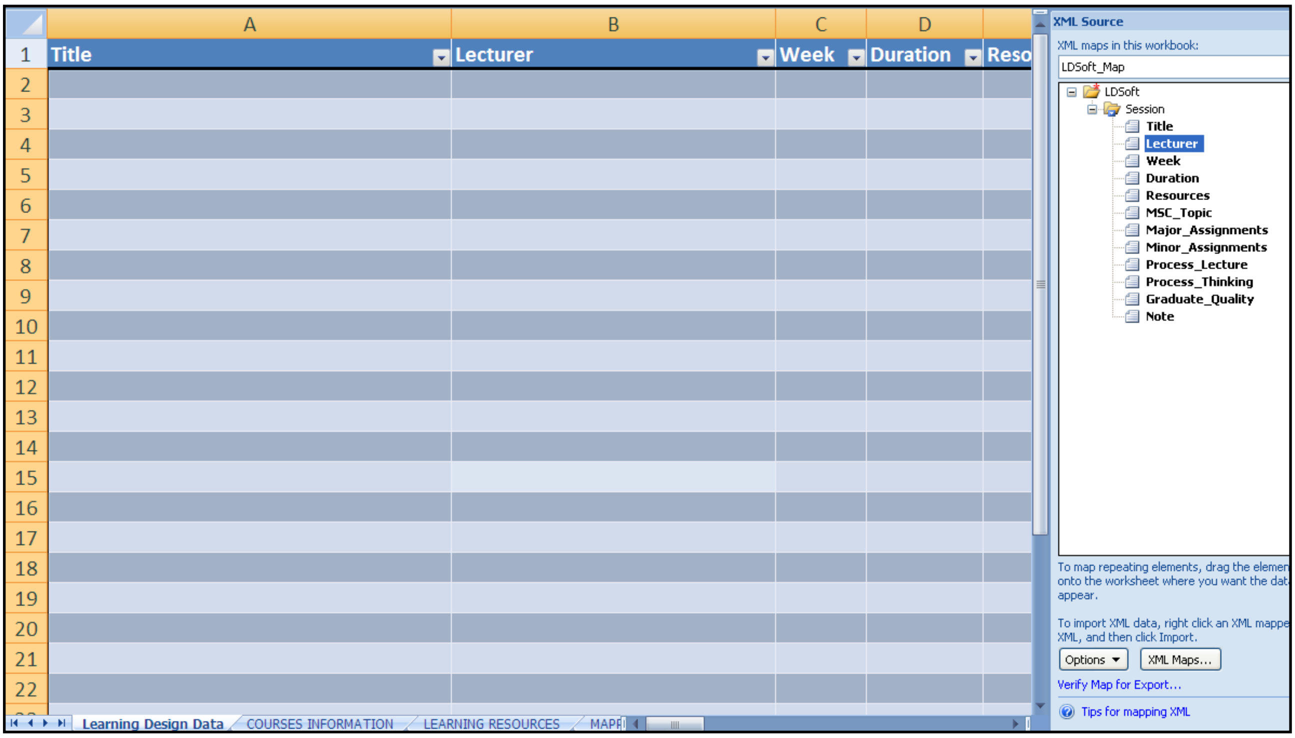


Figure 5.15 Curriculum Reviewer

2) Click import in the *Developer Tab*, then select all LDMaps (Figure 5.16) to be imported by Excel (in this exemplification, two subjects)

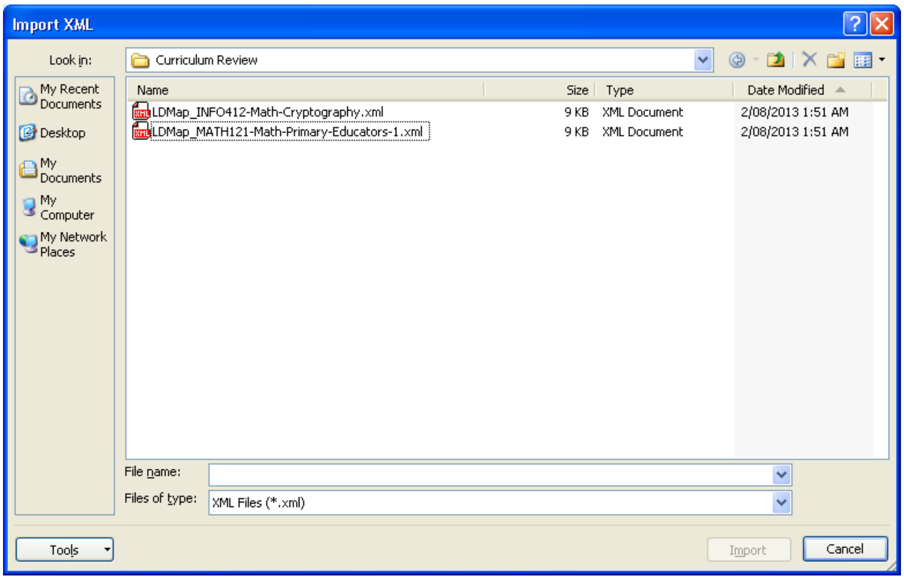
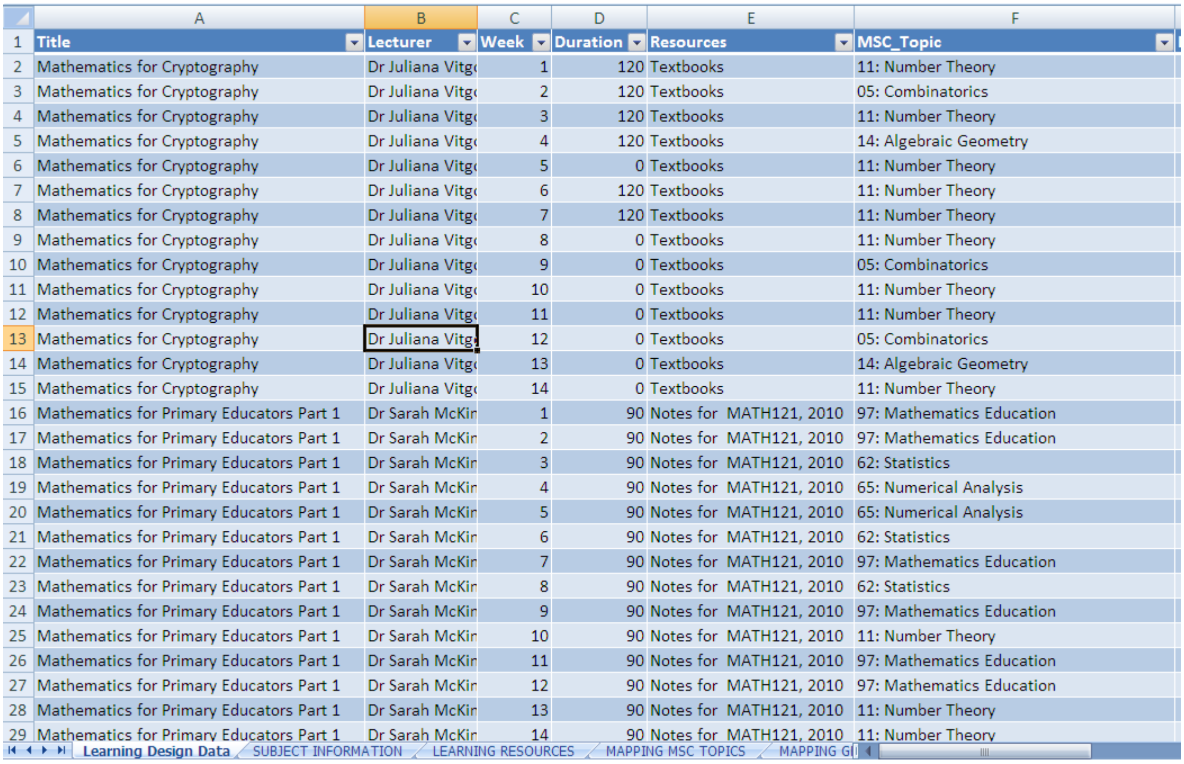


Figure 5.16 Process to import all LDMap files to Curriculum Reviewer

As a result of the import, all the data from all LDMaps was inserted in the *Raw Data* worksheet (Figure 5.17).



	Title	Lecturer	Week	Duration	Resources	MSC_Topic
2	Mathematics for Cryptography	Dr Juliana Vitg	1	120	Textbooks	11: Number Theory
3	Mathematics for Cryptography	Dr Juliana Vitg	2	120	Textbooks	05: Combinatorics
4	Mathematics for Cryptography	Dr Juliana Vitg	3	120	Textbooks	11: Number Theory
5	Mathematics for Cryptography	Dr Juliana Vitg	4	120	Textbooks	14: Algebraic Geometry
6	Mathematics for Cryptography	Dr Juliana Vitg	5	0	Textbooks	11: Number Theory
7	Mathematics for Cryptography	Dr Juliana Vitg	6	120	Textbooks	11: Number Theory
8	Mathematics for Cryptography	Dr Juliana Vitg	7	120	Textbooks	11: Number Theory
9	Mathematics for Cryptography	Dr Juliana Vitg	8	0	Textbooks	11: Number Theory
10	Mathematics for Cryptography	Dr Juliana Vitg	9	0	Textbooks	05: Combinatorics
11	Mathematics for Cryptography	Dr Juliana Vitg	10	0	Textbooks	11: Number Theory
12	Mathematics for Cryptography	Dr Juliana Vitg	11	0	Textbooks	11: Number Theory
13	Mathematics for Cryptography	Dr Juliana Vitg	12	0	Textbooks	05: Combinatorics
14	Mathematics for Cryptography	Dr Juliana Vitg	13	0	Textbooks	14: Algebraic Geometry
15	Mathematics for Cryptography	Dr Juliana Vitg	14	0	Textbooks	11: Number Theory
16	Mathematics for Primary Educators Part 1	Dr Sarah McKir	1	90	Notes for MATH121, 2010	97: Mathematics Education
17	Mathematics for Primary Educators Part 1	Dr Sarah McKir	2	90	Notes for MATH121, 2010	97: Mathematics Education
18	Mathematics for Primary Educators Part 1	Dr Sarah McKir	3	90	Notes for MATH121, 2010	62: Statistics
19	Mathematics for Primary Educators Part 1	Dr Sarah McKir	4	90	Notes for MATH121, 2010	65: Numerical Analysis
20	Mathematics for Primary Educators Part 1	Dr Sarah McKir	5	90	Notes for MATH121, 2010	65: Numerical Analysis
21	Mathematics for Primary Educators Part 1	Dr Sarah McKir	6	90	Notes for MATH121, 2010	62: Statistics
22	Mathematics for Primary Educators Part 1	Dr Sarah McKir	7	90	Notes for MATH121, 2010	97: Mathematics Education
23	Mathematics for Primary Educators Part 1	Dr Sarah McKir	8	90	Notes for MATH121, 2010	62: Statistics
24	Mathematics for Primary Educators Part 1	Dr Sarah McKir	9	90	Notes for MATH121, 2010	97: Mathematics Education
25	Mathematics for Primary Educators Part 1	Dr Sarah McKir	10	90	Notes for MATH121, 2010	11: Number Theory
26	Mathematics for Primary Educators Part 1	Dr Sarah McKir	11	90	Notes for MATH121, 2010	97: Mathematics Education
27	Mathematics for Primary Educators Part 1	Dr Sarah McKir	12	90	Notes for MATH121, 2010	97: Mathematics Education
28	Mathematics for Primary Educators Part 1	Dr Sarah McKir	13	90	Notes for MATH121, 2010	11: Number Theory
29	Mathematics for Primary Educators Part 1	Dr Sarah McKir	14	90	Notes for MATH121, 2010	11: Number Theory

Learning Design Data / SUBJECT INFORMATION / LEARNING RESOURCES / MAPPING MSC TOPICS / MAPPING G

Figure 5.17 Imported Data from LDMap Files

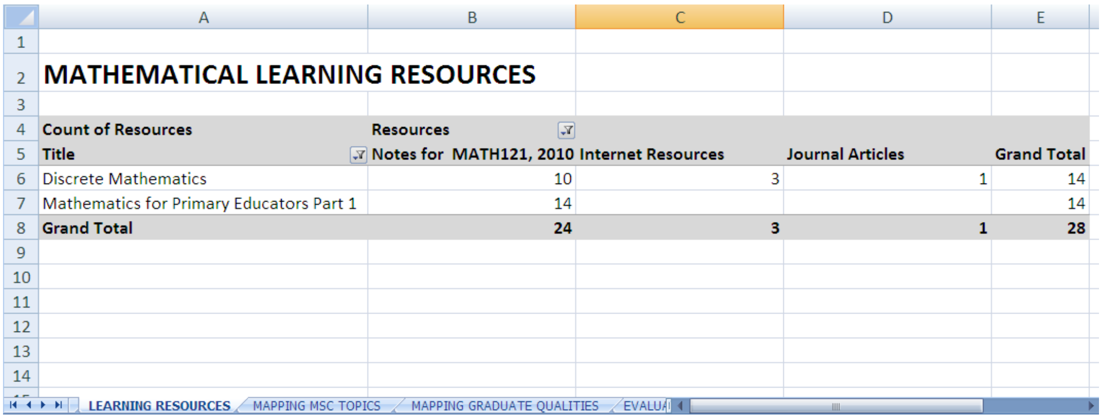
The data contained in the LDMaps is automatically analyzed by the system, within the Learning Design-based Curriculum Reviewer (LDCR) tool. Currently in accord with the LDMaps five types of information are available as a result of the review. The categories of results are grouped within five sections: 1) Subject information, 2) Learning resources, 3) Topics taught as classified with the *Mathematics Subjects Classification*, 4) Distribution of graduate qualities, and 5) Evaluation. If this system is implemented for all subjects in the school or department then the results in overall will reflect the composition of topics or breakdown of graduate qualities addressed. The results can be used 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. In this demonstration the results for each of the five sections are based on only two subjects.

Following is the detailed information and function from each section.

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.



MATHEMATICAL LEARNING RESOURCES

Count of Resources	Resources			
Title	Notes for MATH121, 2010	Internet Resources	Journal Articles	Grand Total
Discrete Mathematics	10	3	1	14
Mathematics for Primary Educators Part 1	14			14
Grand Total	24	3	1	28

Figure 5.18 Mathematics Curriculum Review with Regard to Subject Information

2) Teaching and Learning Methods

This section displays a list of the type of teaching method (discussion, lecture, workshop, presentation, blended learning and hyperlearning) used, available, and expected to be used by lecturer or teacher for all subjects provided by curriculum.

SUBJECT INFORMATION

Process_Thinking	(Multiple Items)		
Count of Process_Lecture	**Process_Lecture**		
Title	**DISCUSSION**	**LECTURE**	**Grand Total**
Discrete Mathematics	1	11	12
Mathematics for Primary Educators Part 1	2	10	12
Grand Total	**3**	**21**	**24**

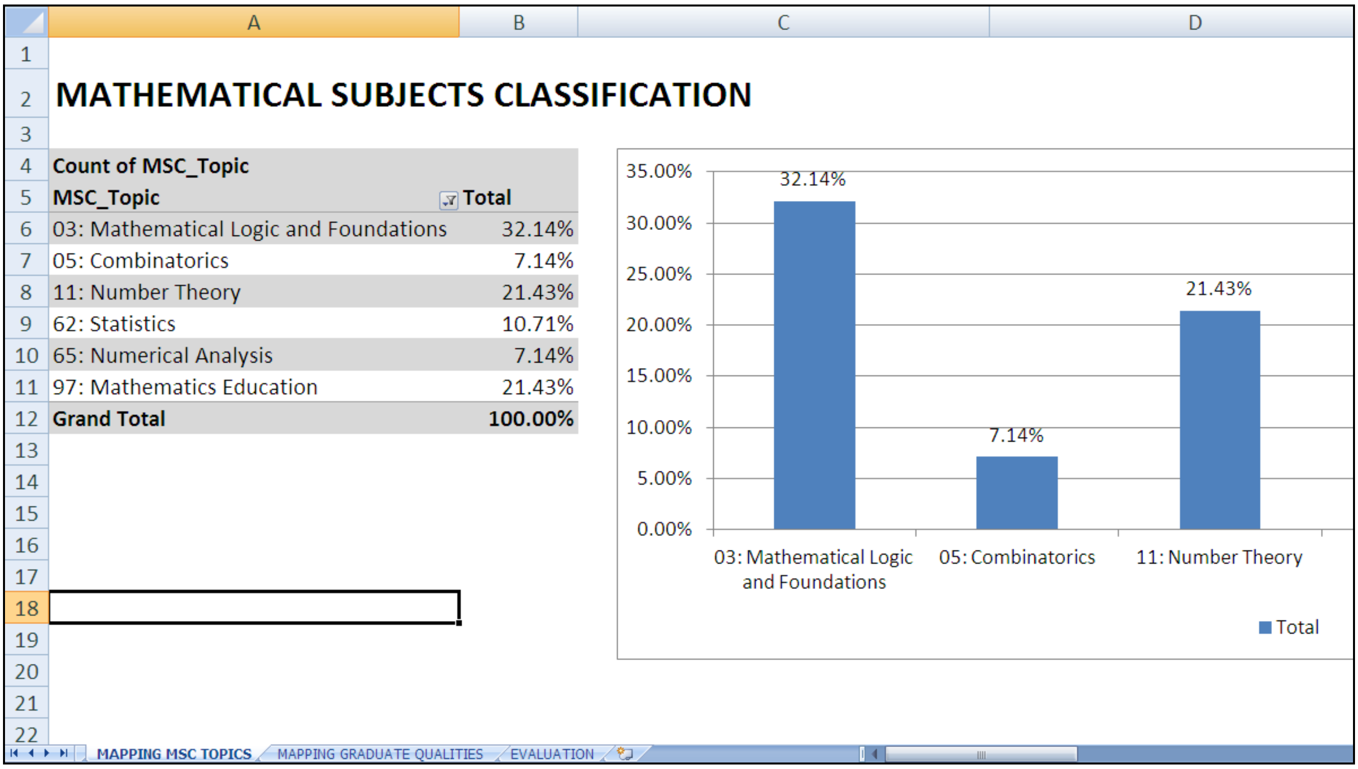
Learning Design Data | SUBJECT INFORMATION | LEARNING RESOURCES | MAPPING MSC TOP

Figure 5.19 Mathematics Curriculum Review with Regard to Teaching and Learning Methods

3) Distribution of *Mathematics Subject Classification*

This section displays distribution of mathematical subjects' classification of subjects provided by the curriculum. 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.

In terms of 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.



MATHEMATICAL SUBJECTS CLASSIFICATION

Count of MSC_Topic	
MSC_Topic	Total
03: Mathematical Logic and Foundations	32.14%
05: Combinatorics	7.14%
11: Number Theory	21.43%
62: Statistics	10.71%
65: Numerical Analysis	7.14%
97: Mathematics Education	21.43%
Grand Total	**100.00%**

Figure 5.20 Review of topics using the *Mathematical Subjects Classification*

More specific classification, deeper levels, for example subtopics for *Mathematical Logic and Foundation*s (such as, explicit machine computation and program, logic in the philosophy of science, general logic), also can be counted and visually displayed using graphics if this information were collected in the LDForm. The maximum number of subtopics to be displayed in the graphics depends on the MS Excel capability to show number of columns in the spreadsheet.

4) Distribution of Graduate Qualities

This section displays the distribution of the five graduate qualities expected through implementation of the curriculum. For example, given the two subjects *Discrete Mathematics* (MATH121) and *Mathematics for Primary Educators*

(MATH131), the results of a curriculum review as displayed in Figure 5.18 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 sampled subjects, this graduate quality dominated the expected graduate qualities to be achieved through the implementation of these subjects, in the current curriculum.

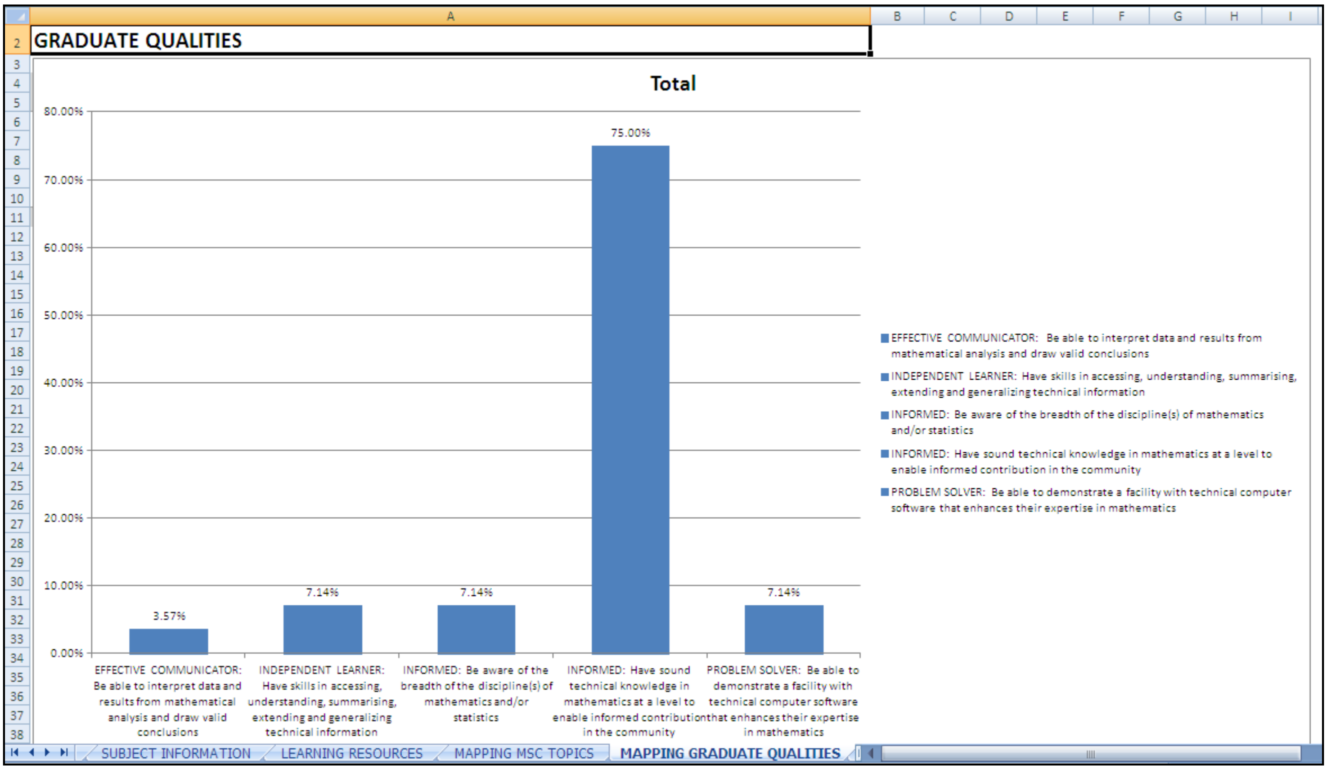


Figure 5.21 Mathematics Curriculum Review with regard to graduate qualities

As with the previous result (*Mathematical Subjects Classification*), information displayed in this section depends on the data recorded using the LDForm. Institutions can set up in the LDForm the list of their expected graduate qualities including subcomponents of each attribute, for selection by lecturers. Then the Learning Design-based Curriculum Reviewer will aggregate the data and visually display the summaries.

5) Evaluation (Assessment)

This section displays the weekly scheduled within-session assessment and the percentage of the evaluation (or assessment) contributed by lecturers for each subject. The final examination or end of session assessment is not included. For example, as displayed in Figure 5.21, evaluation is scheduled in week 7 and week 14, contributing 25, 30, and 40 percent (the data is aggregated for all subjects, so no individual subject can be identified). In week 7, two major assignments contributing 25% and 30%, while for week 14 two major assignment worth of 40% will be happened.

EVALUATION

Sum of Major_Assignments	Major_Assignments			
Week	25	30	40	Grand Total
7	25	30		55
14			80	80
Grand Total	25	30	80	135

Figure 5.22 Mathematics Curriculum Review with Regard to Evaluation

Many other potential outputs can be revealed based on documented learning design in LDMap using LDCR, for example comparing process of learning (lecture, discussion, etc) for each subjects, and relating weekly workload of each lecturers. The potential for outputs depends on information collected using LDForm, as the main function of the LDCR is to aggregate and analyse data and visually display it in the prepared form. New pages would need to be set up in EXCEL to automatically produce the required output for additional topics.

In order to learn from the experience of lecturers with and use of with subject outline templates, curriculum mapping, curriculum review, and mapping learning designs

several academic staff were interviewed. Their experience was to guide future development of the LDMap.

5.4.1.5 Academic staff interviews

The participants in this activity were members of staff who were involved in either curriculum mapping or curriculum review at the University of Wollongong, Australia. The academics were selected using snow ball sampling method, through recommendation from one academic to the others based on their experiences and knowledge of who was engaged in curriculum mapping or automation of subject information sheets.

Three broad question areas were identified for participants in the interviews:

1) What are your experiences with subject outline templates, curriculum mapping and review tools, and learning designs mapping tools and the processes using them? What are the essential qualities of such tools or process for effective use?

2) What issues have you encountered with existing templates or the process for using them? What features make them work, or what features are missing from the existing templates?

3) What is the best way to combine the use of subject outlines, maps of learning design and curriculum?

The participants were asked whether they are interested in providing comments regarding the improvement of the Learning Design Map (LDMap), Learning Design Form (LDForm), and Learning Design-based Curriculum Review (LDCR) applications developed for curriculum review during this research project or if they wished to demonstrate their own tools.

The interviews related activities in this section are listed in Table 5.30

Table 5.30 List of interview activities

No	People/Group	Date	Activity
1	Professor Rene Robinson*	2 November 2012	Demonstration of LDMap, LDForm, and LDCR and Discussion
2	Professor Lucas * Professor Hamilton* Mr Andrew*	27 November 2012	Demonstration of Faculty of Commerce's Curriculum Mapping System and discussion. Followed by trial from researcher to their demo system
3	Dr Richardson*	5 December 2012	Demonstration of LDMap, LDForm, and LDCR followed by Interview
4	Dr Wallace*	5 April 2013	Demonstration of LDMap, LDForm, and LDCR followed by Interview
5	A/Professor Wilson*	2 August 2013	Email commentary about School of Mathematics and Applied Statistics Curriculum, its schematic diagram, and her experience in using Curtin curriculum mapping tool

*pseudonyms

The first interview resulted to information about how to direct the activity of curriculum review at University of Wollongong.

Interviewee 1 is an experienced academic in the field of curriculum mapping and review, and she is also a professor and head in this relevant field at the University of Wollongong. When the researcher demonstrated the analysis of LDMaps containing the learning designs data, with LDCR Prof Robinson drew attention to the mismatch between subject descriptions in units (school or faculty) with the centralised university database. Over time these discrepancies lead to curriculum creep, as lecturers make minor changes to their subject descriptions. To ensure these changes to the formally approved and centrally stored subject descriptions do not occur, one important function is the ability of the curriculum mapping or review tool to be connected to university centralised database, in this case, the subject descriptions will be always consistent with the approved subjects' description. The trend toward web-

based applications for curriculum review is relevant for large institutions, particularly in developed countries that have adequate ICT infrastructure. For institutions in many developing countries, with low levels of ICT infrastructure and facilities available, or for schools, universities or faculties without good ICT infrastructure this degree of integration is not possible, as tools to conduct curriculum review need to appropriate given the existing ICT infrastructure and facilities.

Prof Robinson also indicated that currently at UOW, some faculties and schools implement curriculum mapping or review using a variety of software: For example the Faculty of Commerce and the Faculty of Medicine use their own tools while School of Mathematics and Applied Statistics, was currently implementing the Curtin University excel-based mapping tool. Following this interview, a visit to the Faculty of Commerce was arranged.

The second interview provided practical information about how a curriculum mapping system could be implemented. The Faculty of Commerce, University of Wollongong has established a system for the production of *Subject Information Sheets* that draws subject descriptions from the universities centralized subjects' database system. Subject co-ordinators provide information in variable fields, while data that can be supplied from the central database is automatically included. Administrative staff complete any allowed minor modifications to otherwise locked fields.

In the Faculty of Commerce's system, data input to forms (refer Figure 5.23) produced in web application are available over the web. In this demo system, the researcher trialled the system for MGMT102: Business Communications subject.

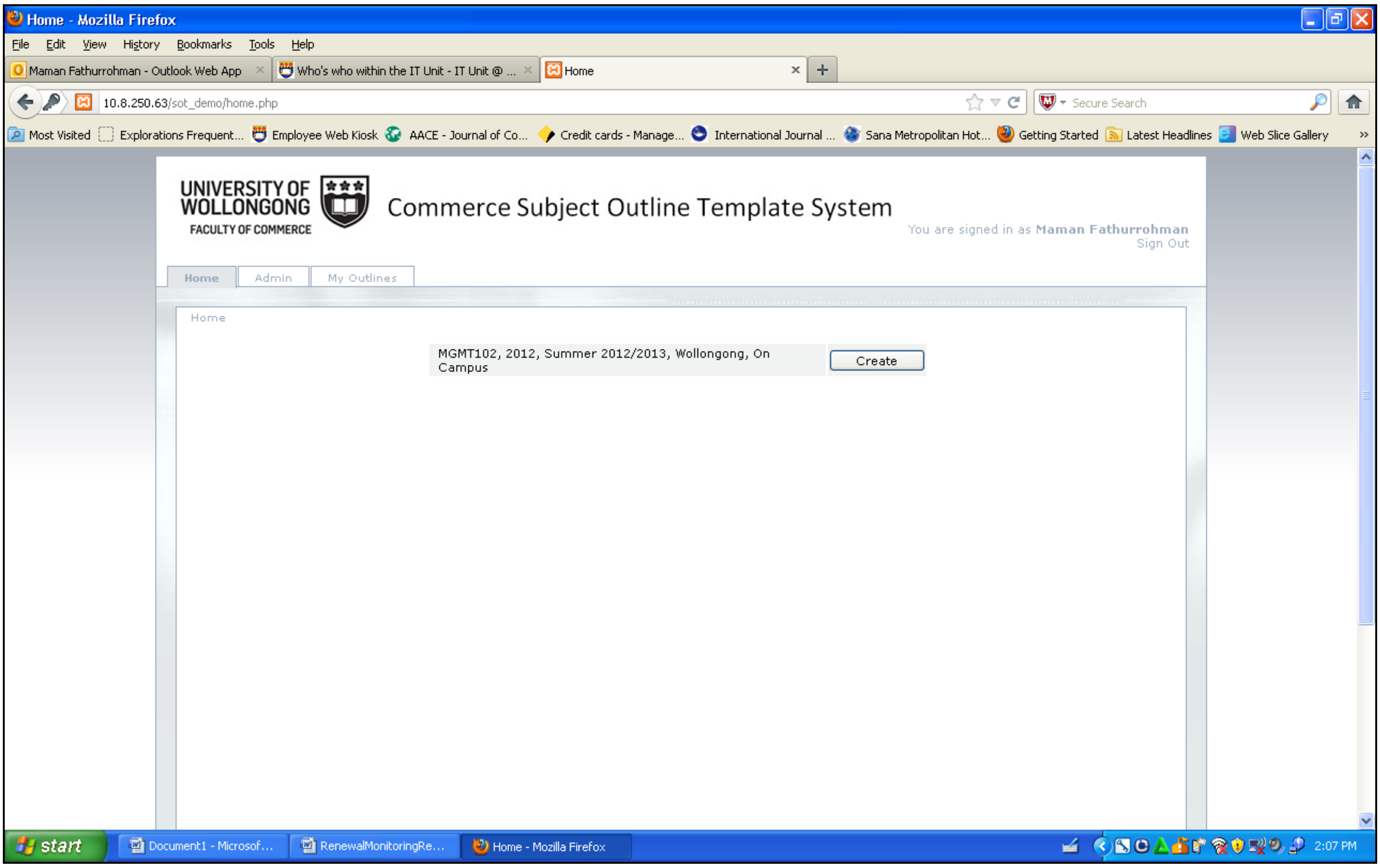


Figure 5.23 Frontpage of the Commerce Subject Outline Template System

The first step was to input data which is consist of two sections: Section A: General Information and Section B: Assessment (refer Figure 5.24). The main purpose of the Faculty of Commerce mapping was to gather data from lecturers in regard to their subjects, and to create the subject outline template for them, with some fields fixed and not changeable and other fields modifiable as suited the lecturer.

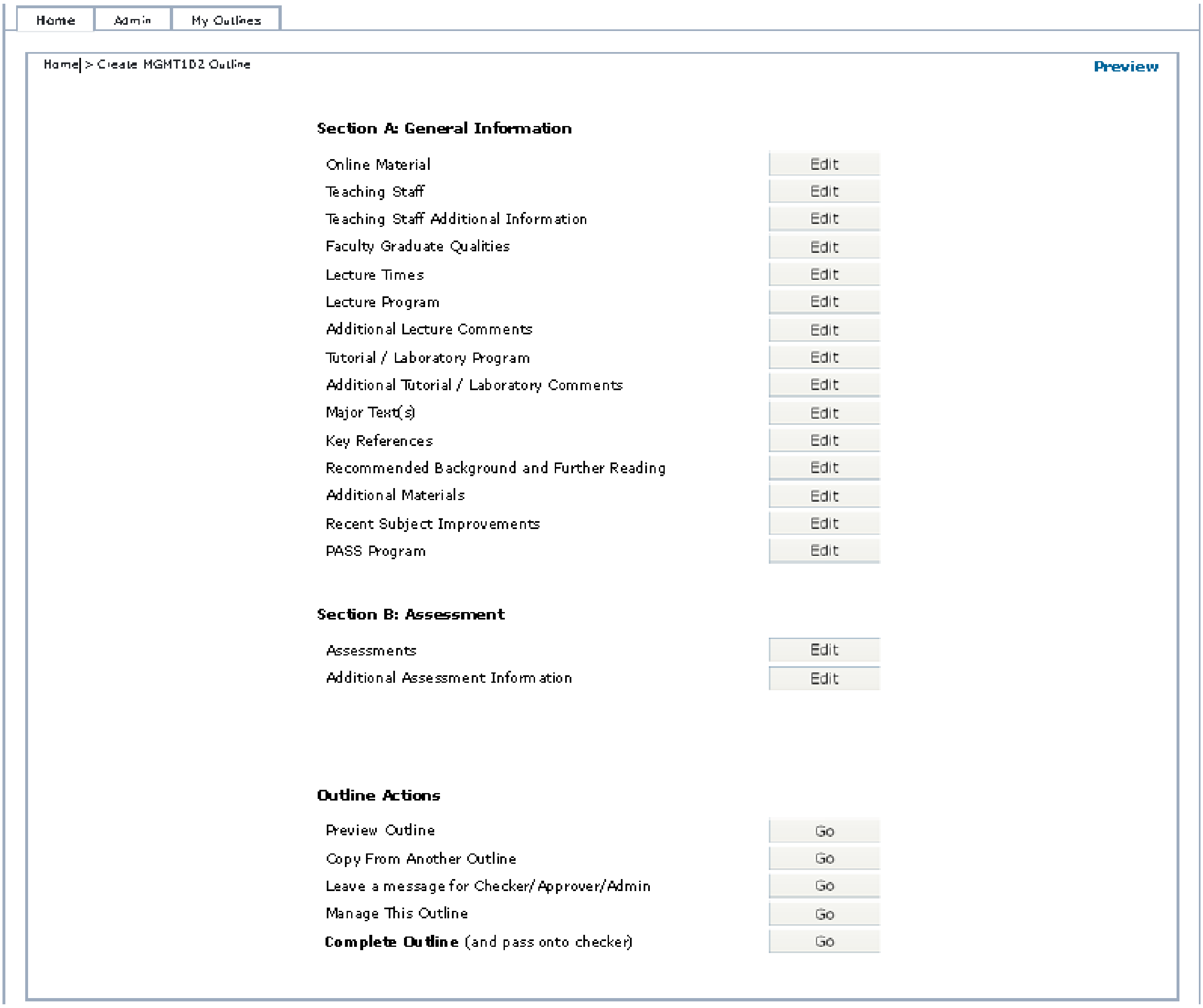


Figure 5.24 Data gathered in the Commerce Subject System

For example in the *Edit Teaching Staff* page, there is a page to input the details of the subject lecturer and coordinator, his/her room number, and the available consultation times for students (refer Figure 5.24).

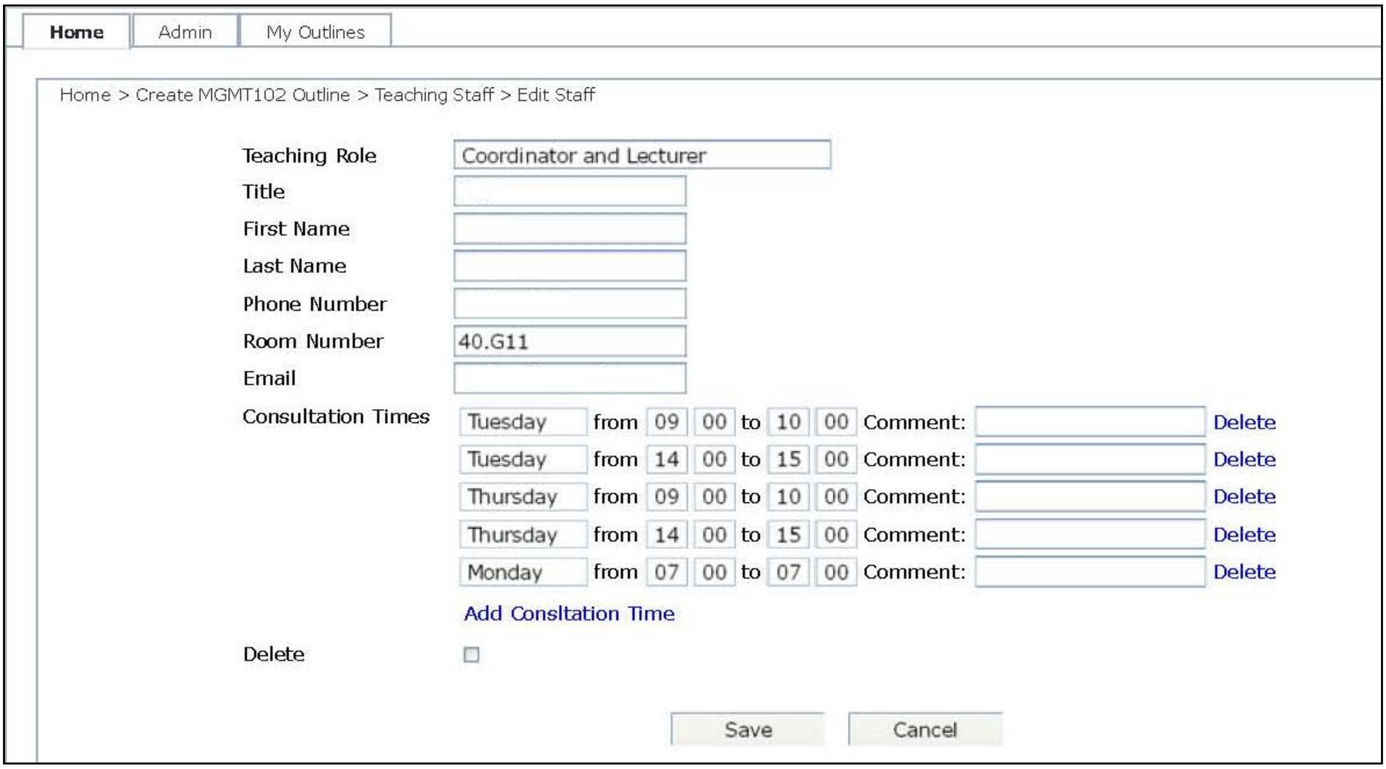


Figure 5.25 Data gathered in the Commerce Subject Information Sheets

Another example of a variable field modified by the lecturer relates to information about major texts used for the subject (refer Figure 5.26)

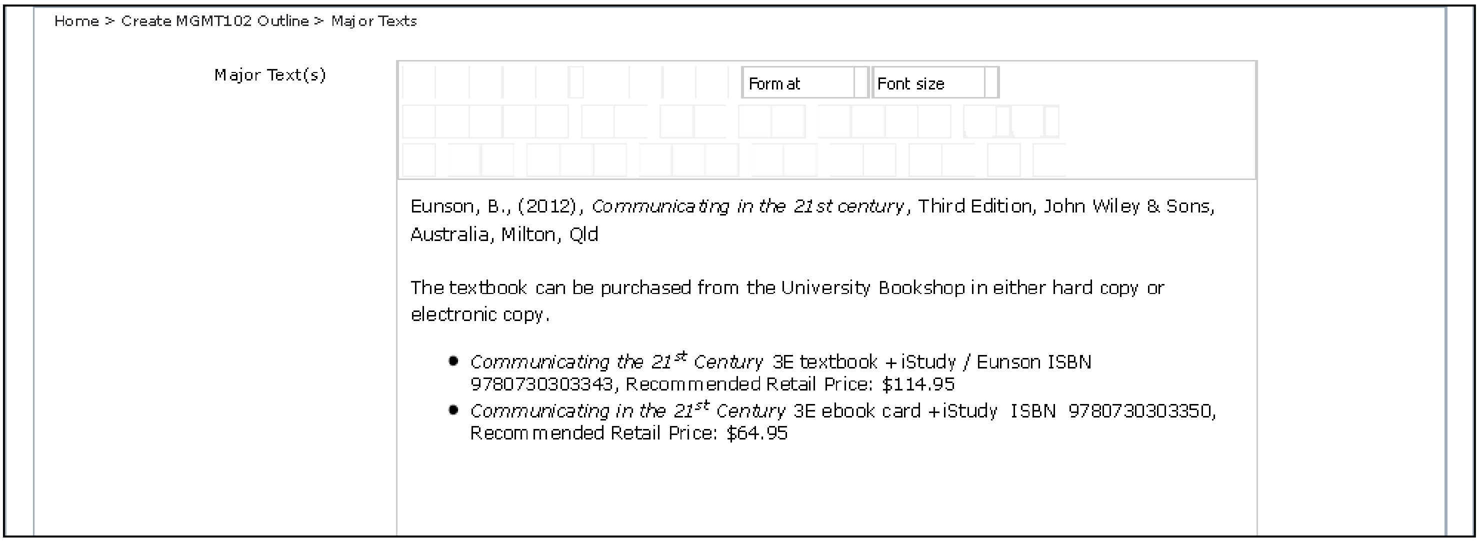


Figure 5.26 Data gathered in regard to major texts used by a lecturer

Important information to be collected in the subject data is the graduate qualities for the Faculty of Commerce. For this section, a lecturer can select graduate qualities addressed in the subject (refer Figure 5.27)

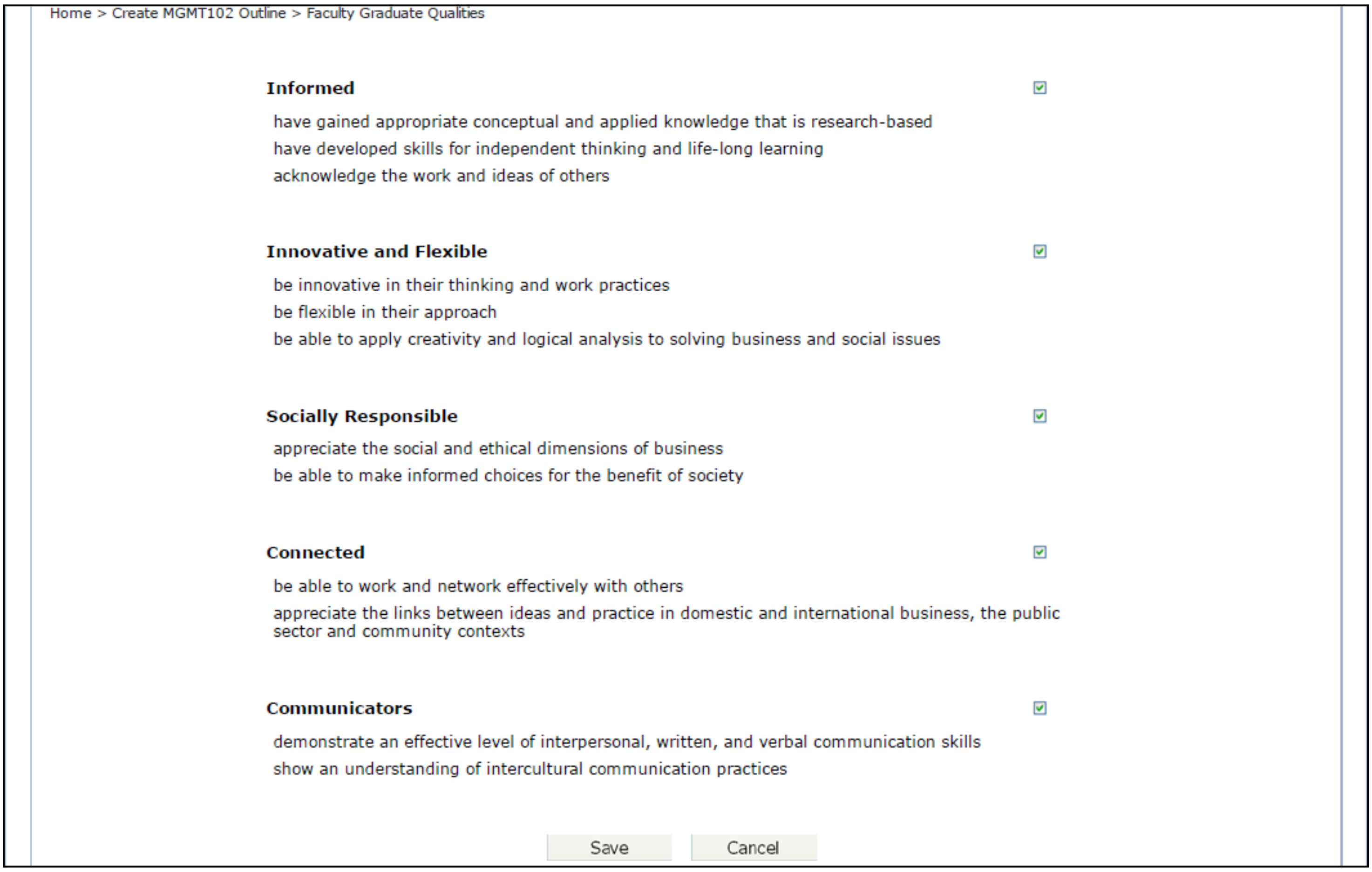
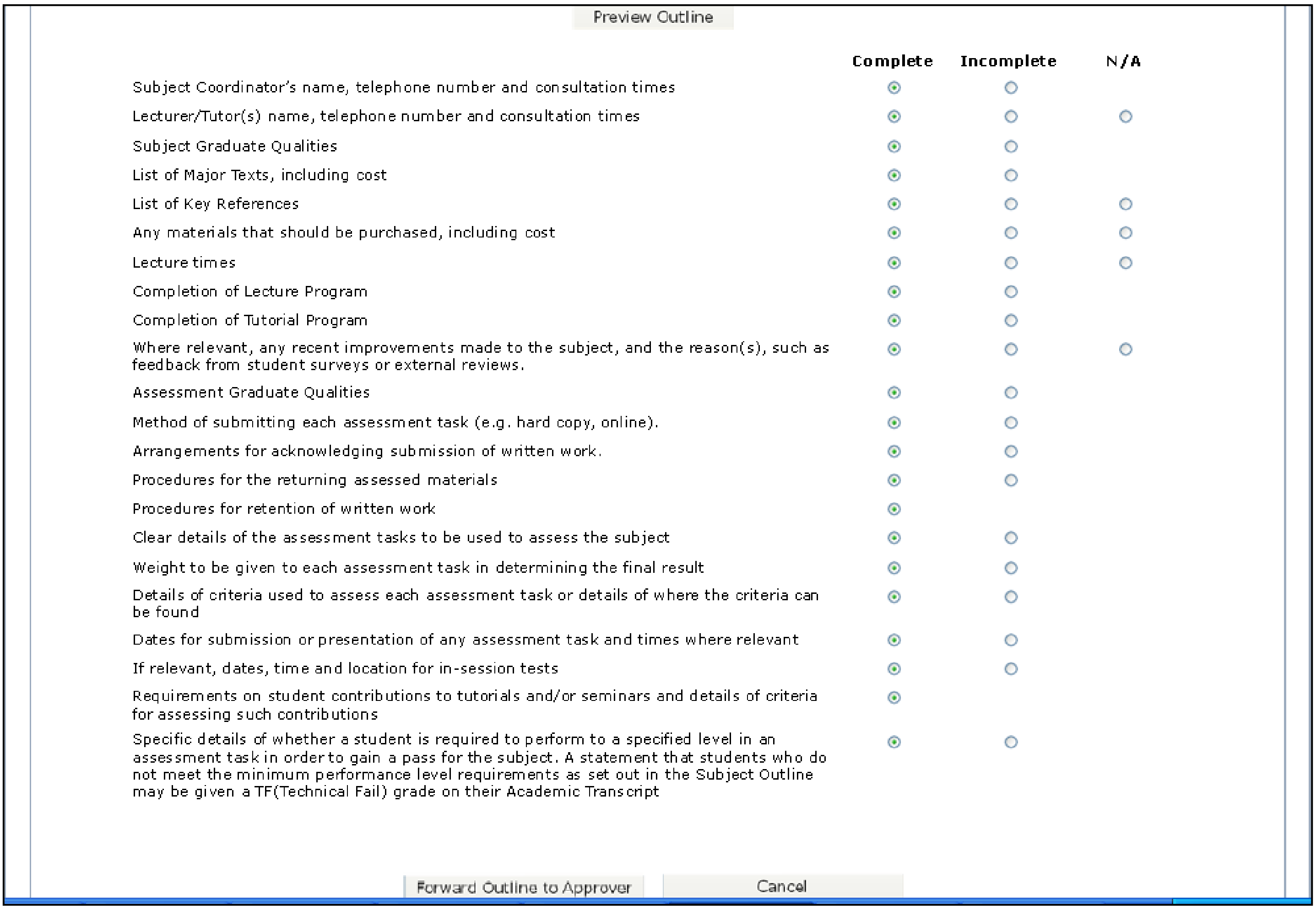


Figure 5.27 Data gathered regarding graduate qualities for the Faculty of Commerce

Lastly, there is also a *Preview of Outline* or checklist to check whether all data required is completed. If already completed, the subject outline can then be sent for approval by the approver (or subject coordinator)



Preview Outline

	Complete	Incomplete	N/A
Subject Coordinator's name, telephone number and consultation times	◉	○	
Lecturer/Tutor(s) name, telephone number and consultation times	◉	○	○
Subject Graduate Qualities	◉	○	
List of Major Texts, including cost	◉	○	
List of Key References	◉	○	○
Any materials that should be purchased, including cost	◉	○	○
Lecture times	◉	○	○
Completion of Lecture Program	◉	○	
Completion of Tutorial Program	◉	○	
Where relevant, any recent improvements made to the subject, and the reason(s), such as feedback from student surveys or external reviews.	◉	○	○
Assessment Graduate Qualities	◉	○	
Method of submitting each assessment task (e.g. hard copy, online).	◉	○	
Arrangements for acknowledging submission of written work.	◉	○	
Procedures for the returning assessed materials	◉	○	
Procedures for retention of written work	◉		
Clear details of the assessment tasks to be used to assess the subject	◉	○	
Weight to be given to each assessment task in determining the final result	◉	○	
Details of criteria used to assess each assessment task or details of where the criteria can be found	◉	○	
Dates for submission or presentation of any assessment task and times where relevant	◉	○	
If relevant, dates, time and location for in-session tests	◉	○	
Requirements on student contributions to tutorials and/or seminars and details of criteria for assessing such contributions	◉		
Specific details of whether a student is required to perform to a specified level in an assessment task in order to gain a pass for the subject. A statement that students who do not meet the minimum performance level requirements as set out in the Subject Outline may be given a TF(Technical Fail) grade on their Academic Transcript	◉	○	

Forward Outline to Approver | Cancel

Figure 5.28 Data gathered in the Commerce Subject Information Sheets

For lecturers, the final result of this system is a *Subject Information Sheet* in a Microsoft word document that can be distributed to students, while for faculty all data submitted by all lecturers can be exported as statistical data in an excel file for manual use by faculty management undertaking curriculum review.

creating better futures
http://www.uow.edu.au/commerce

DRAFT

School of Test

MGMT102: Business Communications

Subject Outline
6 credit points

Subject Information

Summer 2012/2013
Wollongong
On Campus

Lecture Information:
Tuesdays, 10:30 - 12:30, 32-G01
Thursdays, 10:30 - 12:30, 32-G01

Pre-requisites: Nil
Co-requisites: Nil
Restrictions: Nil
Contact Hours: 4 hours lecture and 2 hours tutorial
Online Subject Material:
http:www.uow.edu.au/student/elearning/vista/index.html

Teaching Staff

Teaching Role	Coordinator and Lecturer
Name	
Telephone	4221 3796
Email	
Room	40.G11
Consultation Times	Tuesday 09:00 - 10:00 Tuesday 14:00 - 15:00 Thursday 09:00 - 10:00 Thursday 14:00 - 15:00

Teaching Role	Tutor
Name	

Figure 5.29 Automated completion of Commerce Information Sheet

At the time of the discussions, the system to produce subject information sheets was in use and under refinement however learning designs were not mapped in this process. The Faculty of Commerce mapping tools reinforced for the researcher that at least in the UOW context that through the process of collecting data for learning designs and curriculum review that the mapping tools should be able to produce

ready to distribute information sheets for students, thus removing some of the burden by aligning the curriculum mapping task with that of subject outline production.

The first and second interviews showed the necessity in developed countries for web-based software applications connected to centralised databases for use by lecturers for curriculum mapping or review. To be implemented, this type of application usually has fixed forms and procedures, and needs considerable support from skilled staff in ICT along with relevant permissions. In this case the modification of the application and implementation at other institutions will have high level of difficulty.

Issues arose given the context beyond the scope of this thesis, these pertain to ownership and sharing. In Australia, intellectual property rights vary from university to university and for different classifications of staff (casual or fulltime, academic or administrative) and students. At the University of Wollongong, the *Subject Information Sheet*, an administrative document is the intellectual property of the University and as such may not be shareable without permission. According to Porter and Denny (2013, p. 46), ownership of copyright in teaching materials at UOW resides with the creator of the materials and they may grant a license, such as Creative Commons, for others to use these materials. The same does not apply to a LDMap, which can be used to generate a subject outlines, this software through this thesis is available under Creative Commons license. The researcher's focus was on the use of LDMap to enable lecturers to document and share their own learning designs, and in this case the subject outline is simply one product of the process. However if the tools is to be shared in UOW Shareworld (see section 6.4 dissemination) the UOW staff who make a contribution to the Share World collection are also required to acknowledge that have the right to contribute the resources and that they are indeed teaching resources, not administrative resources (Porter and Denny, 2013, p. 46). In the case of lecturers moving from one institution to another institution they still can use their own learning designs documented in LDMap for review of their subjects. Intellectual property rights aside, in the future and in developed countries it is likely that for curriculum review, Web-based applications of LDCR, will be required to readily analyse LDMaps from all lecturers.

The third interview provided information from an experienced researcher in the area of learning designs. This lecturer is currently a learning designer at the University of Wollongong and her PhD thesis research was focused on learning design. Dr Richardson provided advice that the learning design information should be detailed in learning design forms in order to support the sharing of teaching and learning design among educators. The learning design should be visually displayed for ease of understanding and she concurred that resource data, tasks, and supports to show how teaching and learning to be conducted is important data to collect. She recognised that in practice it is rather difficult to manually create diagrams to represent learning designs and included in this the difficulty of displaying representations of learning designs in web-based applications or in browsers.

The fourth interview provided information from an experienced academic member of staff on the topic of curriculum review. After she saw the researcher's demonstration on how LDMaps can be analysed using LDCR for use in curriculum review, Dr Wallace while applauding the functionality of the LDMap provided advice about sustainability. One of her key concerns in relation to curriculum mapping is the identification of a group of people to manage the software and its products, that is the data in the long term needs to be appropriately stored and accessible. From an organisational perspective, when lecturers are responsible for the maps they can be readily lost to the organisation as people for example move to other positions. If the tools and data are to be sustained and maintained, written documentation with contact for support and help is required as is a person responsible for the data for implementation in curriculum reviews.

Oliver, Fern, Whelan, and Lilly (2010) reported the benefits from current excel-based Curtin mapping tools for mapping graduate qualities and stated that 11 other universities already use it. The report also said that a web-based application version of their tool that connected to university databases will be a future development. Not all users have the same experience. In an email commentary, Professor Wilson discussed the current structure and content of School of Mathematics and Applied Statistics curriculum and provided a schematic diagram showing the relationship

between subjects. She also explained difficulties and limitations experienced in conducting a review of mathematics using the excel-based Curtin tool. This academic commented:

> *Hence, there is a lack of arbitrariness [possibly the availability to satisfy the need of curriculum review at School of Mathematics and Applied Mathematics] in the Curtin Tool and therefore one of the down points of the tool.*
>
> *The spreadsheet was inflexible it was hard to add information. Some of the questions were not suitable for our institution - but that is what you expect!*
>
> *Undertaking the mapping tasks was time consuming. Basically a lot of it was done by myself as if I gave it to each staff member there would be no consistency and therefore corrupted data.*

Usability is a key feature for this academic. Addressing issues with respect to improving usability, particularly in terms of enabling the modification of the forms for data collection and output were of key concern in this project.

5.4.1.6 Enabling modifiability

There are many schools of mathematics in the world. As indicated in the interviews each school may have different needs for conducting curriculum reviews. In order to improve the usability of the tool for use in curriculum review by other institutions or faculties, the tool, in particular the LDForm, to some extent must be modifiable. The modifiability of the LDForm means that it is customisable by the educator, school or university for use in curriculum review for their own unit. The modifiability feature of LDForm is essential if this tool is to be made available and useful for many schools or universities in their activities of curriculum review.

The key in making successful modifications to the LDForm and LCDR is by keeping consistency (or equivalency) of LD Maps structure between the LDForm and LDCR.

The equivalence between XML maps can be ensured by making the XML nodes both name and order on the LDForm the same as in LDCR (refer Figure 5.30). LDMap in this system functions as a “bridge” between LDForm and LDCR to enable learning design data captured using LDForm to be transferred to LDCR for use in curriculum review. The data from each LDForm is automatically placed in a section called *Subject Review* and from here it is exported to an LDMap. Ideally these are collected together and stored in a dedicated folder. All these maps, generated to have the same nodes, in the same order are then imported to the LDCR section *Learning Design Data*. From this the review is conducted with automatic generation of the summaries for each node of data collected.

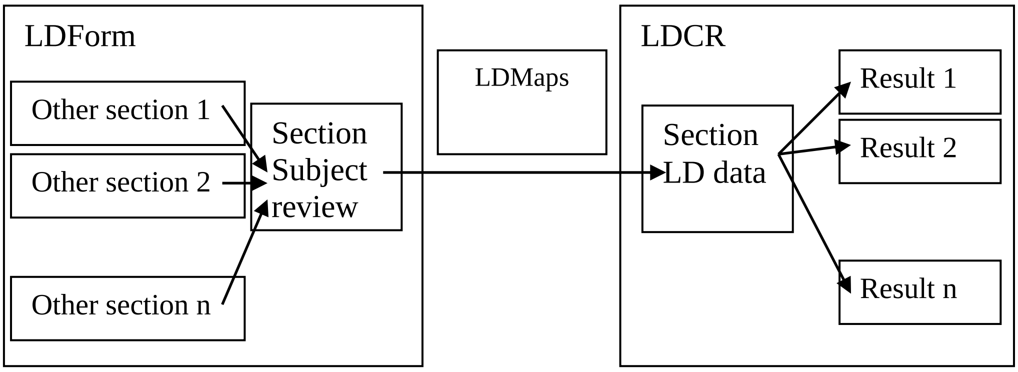


Figure 5.30 Modifiablity concept

Modification of the LDForm and LDCR is conducted based on the concept of keeping the consistency or equivalency of LDMaps with the LDForm and LDCR (see Figure 5.30). Educators and their institutions can modify the LDForm and LDCR, as long as the exported XML maps from LDForm and the imported maps for LDCR are kept the same. Modification in sections such as *Frontpage*, *first half-semester*, *second half-semester*, and the *Subject Information Sheet* need corresponding changes, to the results or review of output sections in LDCR.

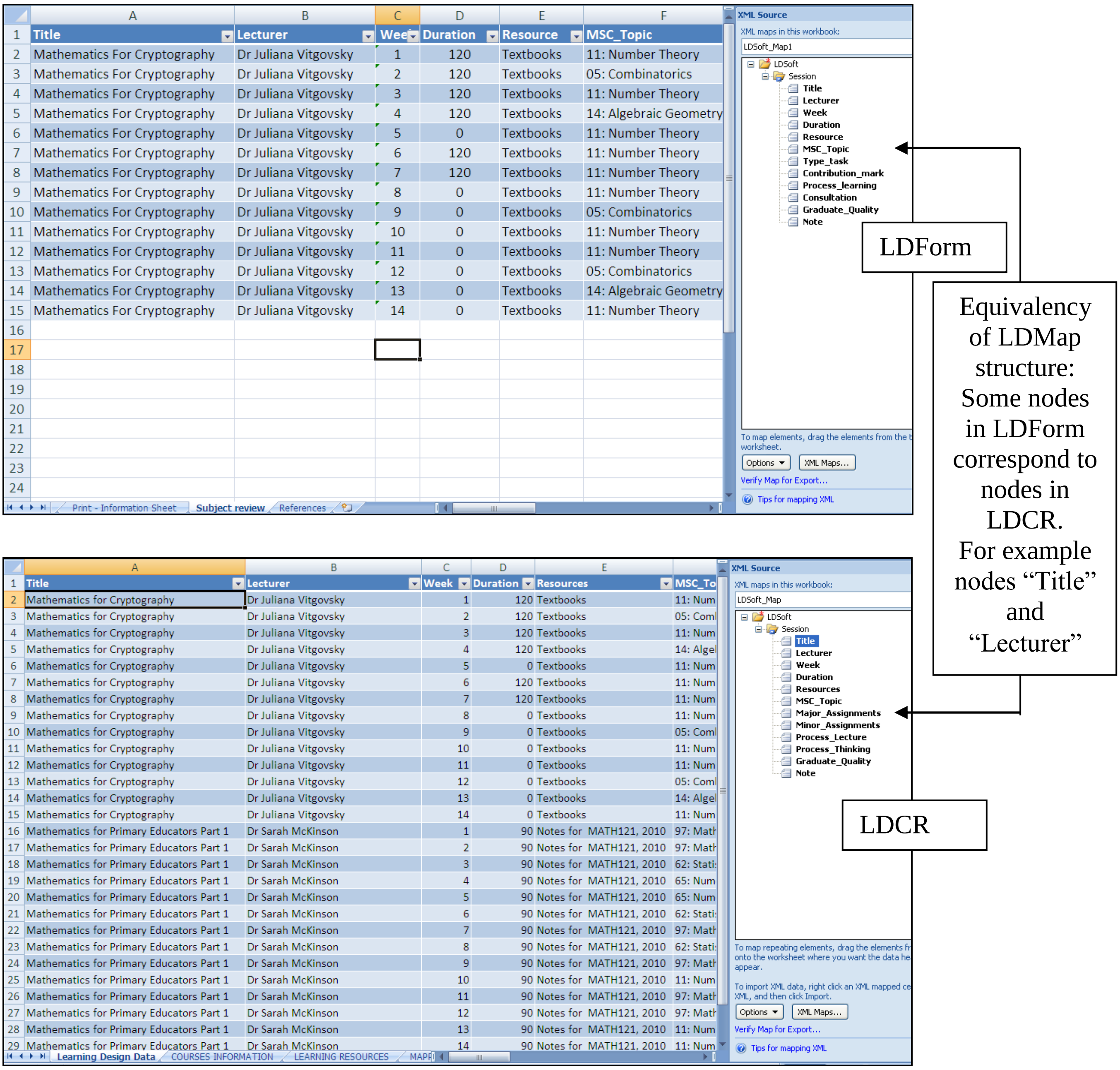


Figure 5.31 Equivalency of LDMaps structure between LDForm and LDCR

The modification of LDForm can be categorized as one of two types, changes to drop down categories and the addition, deletion or changes to fields (for example addition of a new variable field *working skills* and the associated categories for the drop down menus). Although an educator can modify the LDForm, it is expected that

modification of LDForm and Curriculum Reviewer are approved by the school, to make sure that the LDMaps structure that form the bridge between LDForm and LDCR are equivalence so that the review can be conducted for the organisational unit.

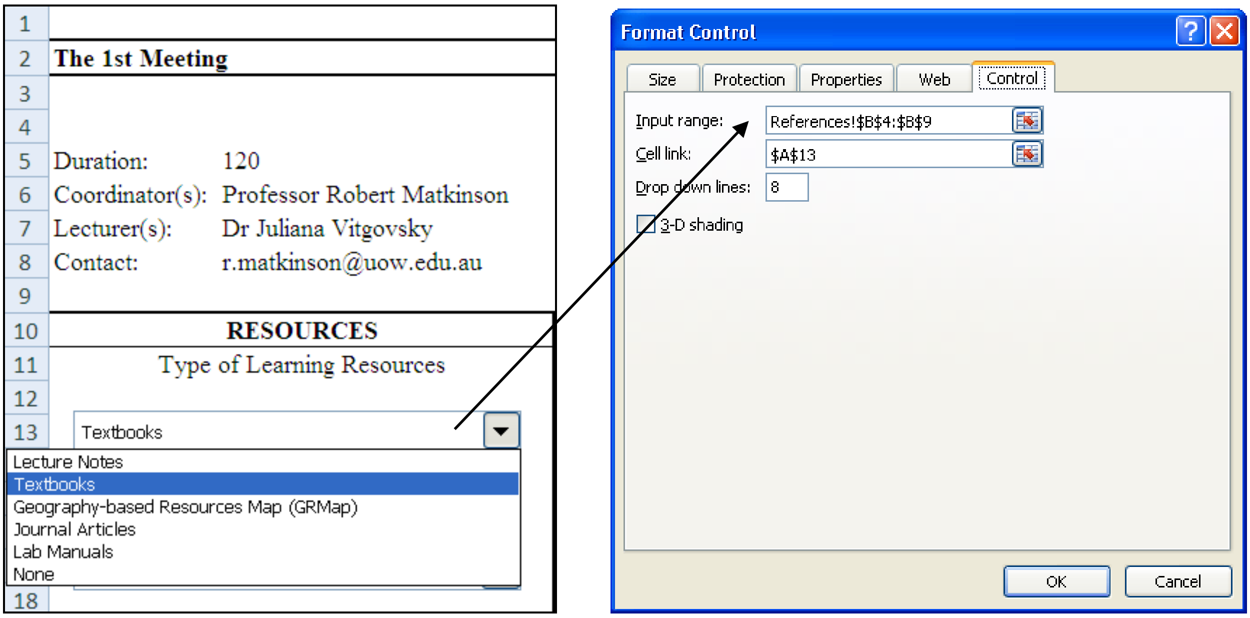
1) Changes to drop down categories.

To change a category name listed in the dropdown list (for example in name of learning resources: textbooks, journal articles) the source of the category name in the section *References* needs to be changed. To do this user can modify the category names for the node *Name of Learning Resources*, for example, *text book*, in the list item in section *References* as shown in Figure 5.32.

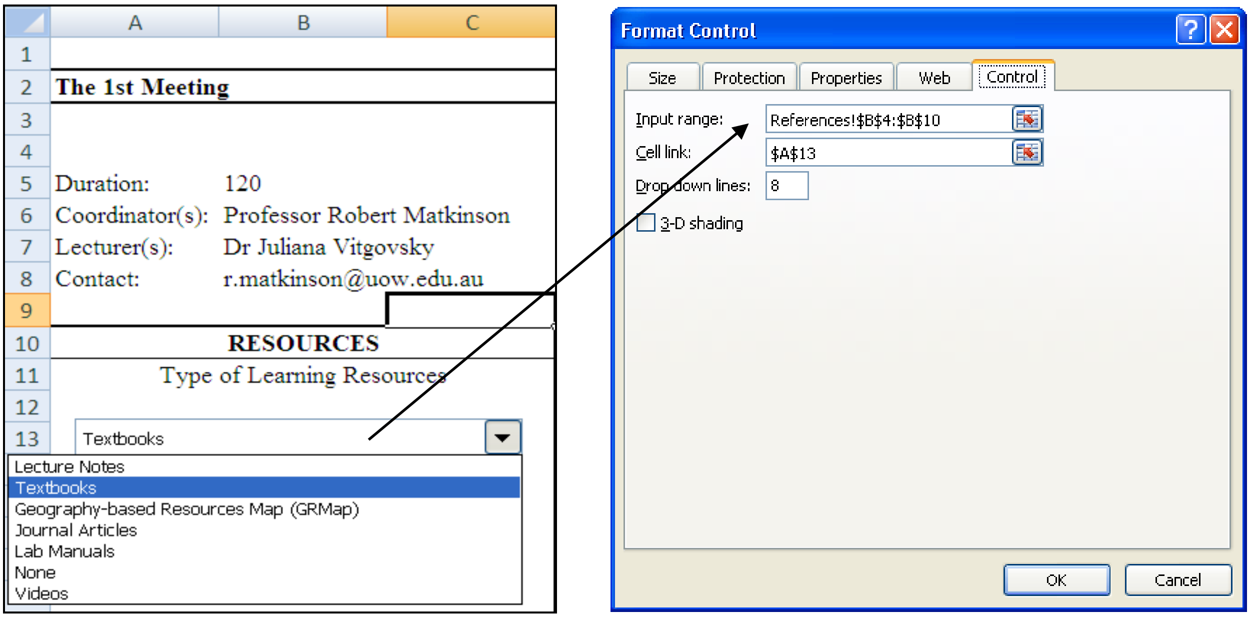
	A	B	C	D	E	F
1	**LIST OF REFERENCES (Changes in this list of references will be reflected in the previous sections)**					
2						
3	Name of Learning Resources					
4	1	Lecture Notes				
5	2	Textbooks				
6	3	Geography-based Resources Map (GRMap)				
7	4	Journal Articles				
8	5	Lab Manuals				
9	6	None				
10						
11	MSC Code					
12	1	00: General				
13	2	01: History and Biography				
14	3	03: Mathematical Logic and Foundations				
15	4	05: Combinatorics				
16	5	06: Order Theory				
17	6	08: General Algebraic Systems				

Figure 5.32 List of References

To add a new item to the drop down menu users can change the range of the associated dropdown menu to include new items under *None* at B9. For example in the original data the range is from cells B4 to B9 (*Lecture notes* to *None*) refer Figure 5.32, by including the new cell below B9, for example *Videos*, the range need to be changed to include cells B4 to B10.



BEFORE (without the *videos* option)



AFTER (with “videos” option)

Figure 5.33 Effect of changes in Section *References*

2) Addition, deletion and changes to fields (variable). To add or delete fields, educators need to modify the LDMaps structure.

Step 1) To add or delete nodes (variables), educators must enable the *Developer Tab* in their Microsoft Excel. To do this, Open Microsoft Excel application select the Excel *Options* button then *Popular* and then checked *Show the Developer Tab in Ribbon*

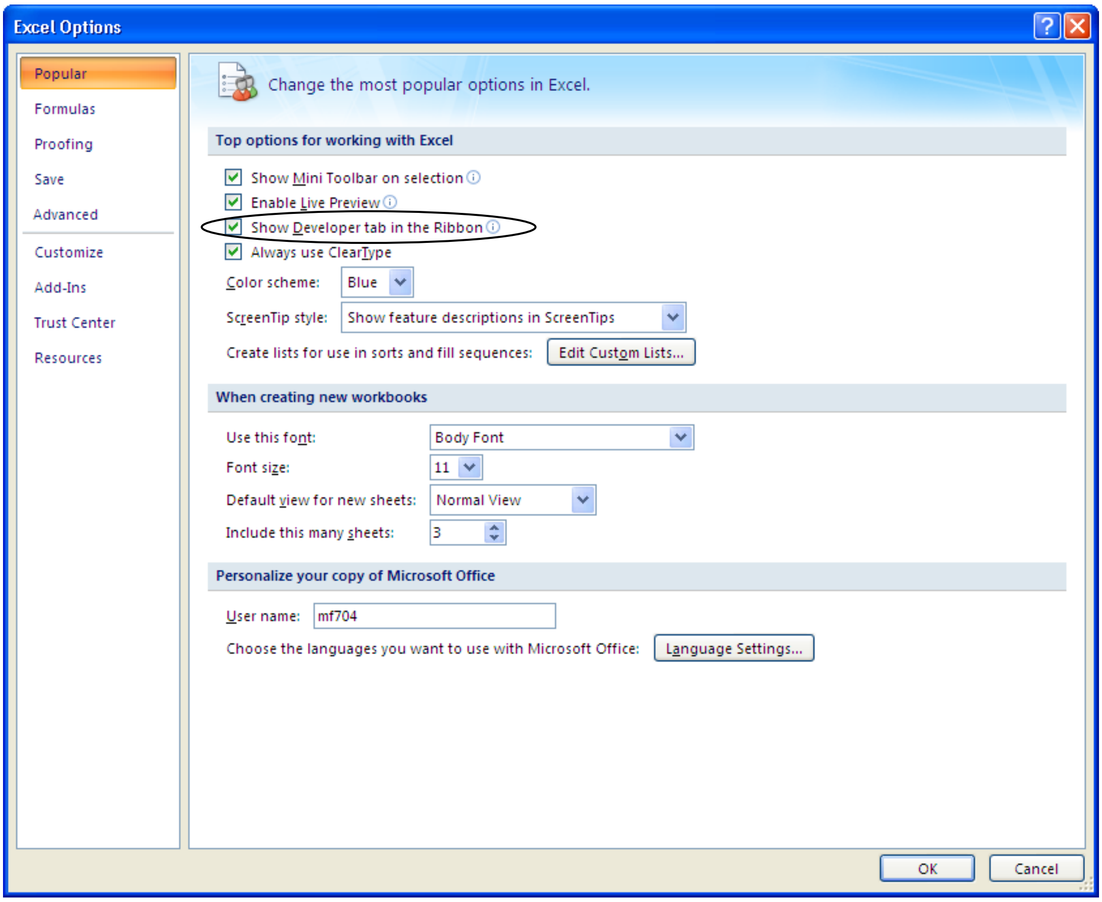


Figure 5.34 Enabling Developer Tab in Ribbon

Step 2) Modify the nodes. The LDMap files can be opened in notepad. To add the fields, the nodes in XML that corresponds to the LDMap need to be modified. In the example in Figure 5.35 a new node *working skills* is added in the required position.

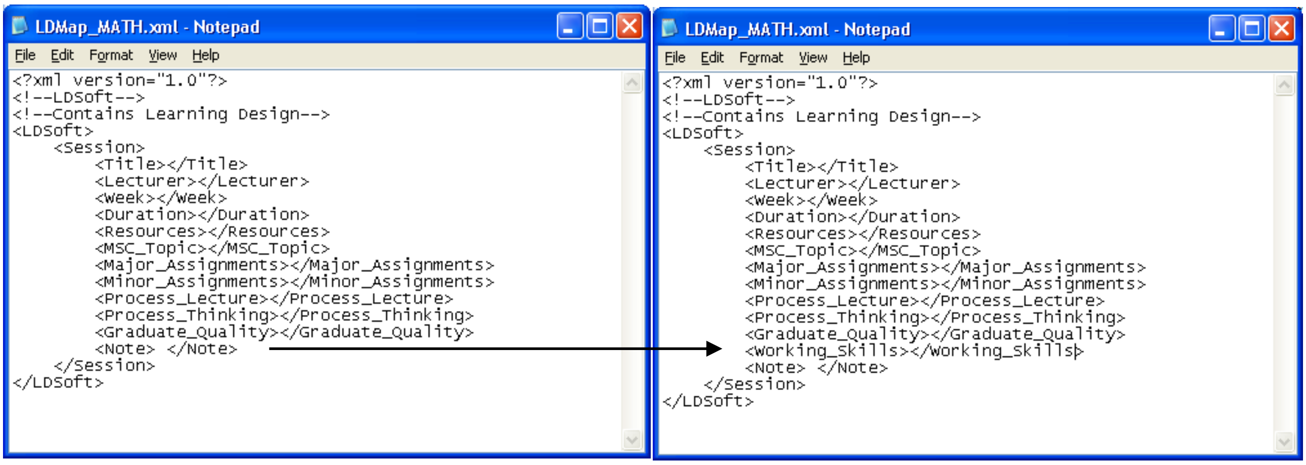


Figure 5.35 Addition of a node in the XML map

Step 3) The XML map file (that is the LDMaps of Maths) saved at *Step 2* can now be opened in LDCR using XML maps option to replace the previous XML map file (without node *working skills*) (refer Figure 5.36).

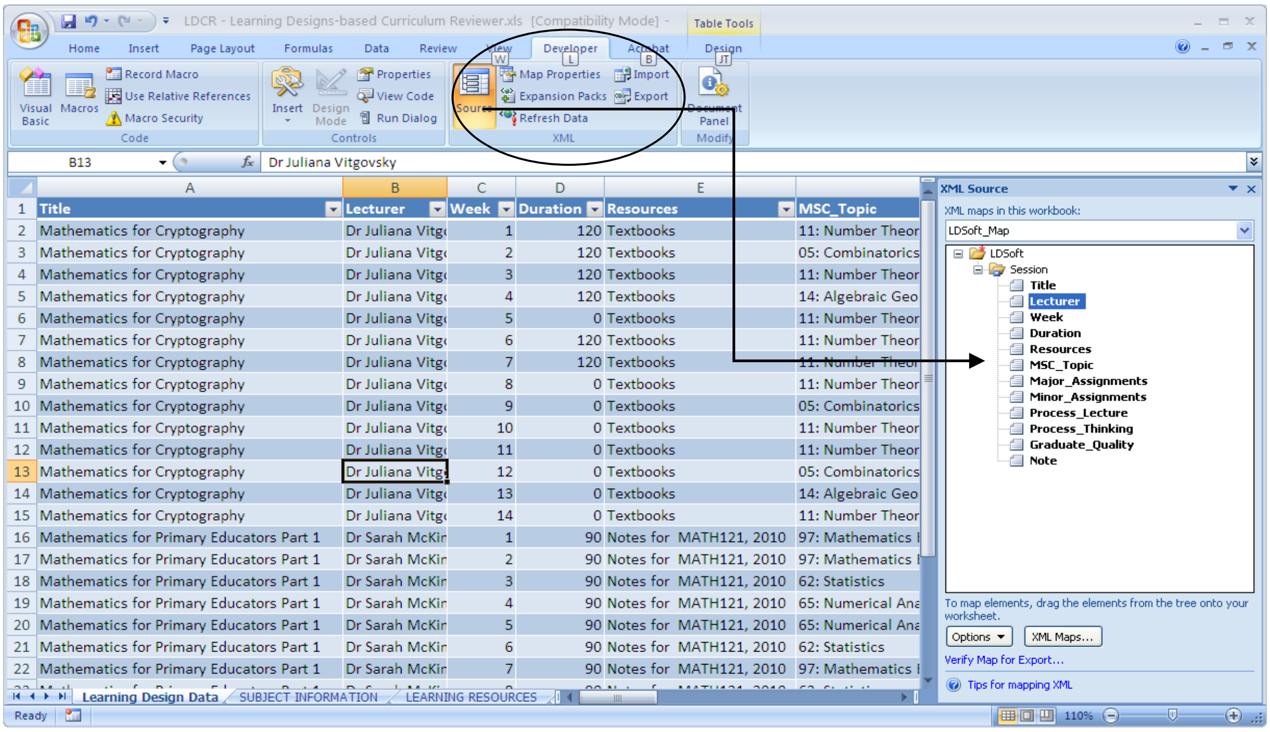


Figure 5.36 Showing the XML source pane

Step 4) Only one file of LDMap with the same nodes and sequence of nodes can be used to map the data collected from LDForm for used in curriculum review using LDCR. Hence the LDMap structure must be deleted first before the new modified XML files can be imported and used in LDCR.

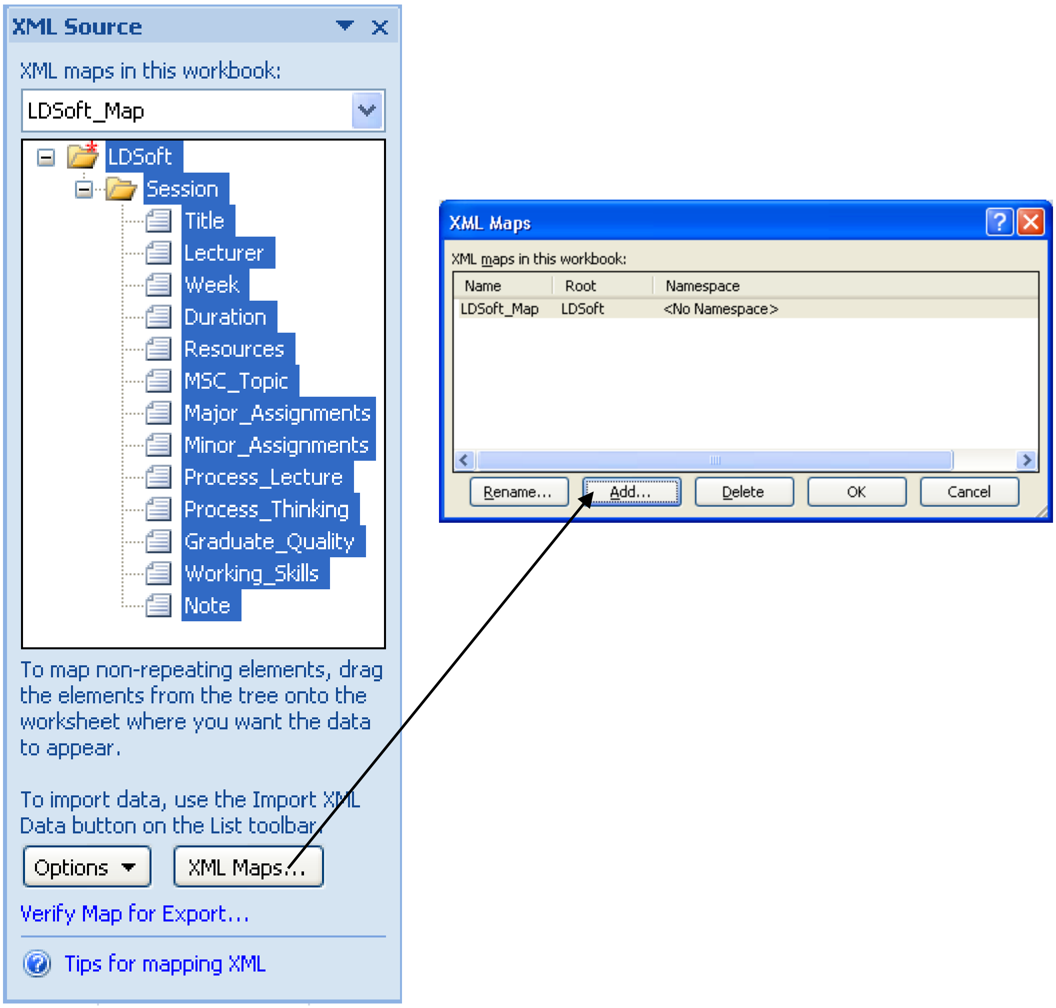


Figure 5.37 Open new modified LDMap using XML Maps button in Excel

Step 5) After successfully importing modified LDMap file, educators or its institution can map this new structure in section Subject Review, to collect data created from other section to be exported to LDMap.

5.5 Embedded learning support systems

In this section improving the usability of the electronic mapping system is explored through the demonstration of the creation of an embedded learning support system, known as Learninglinks for one mathematics subject, MATH142 at the University of Wollongong. In the process of developing the embedded support system usability in terms of added functionality was also addressed.

5.5.1 Creating MATH142 Learninglinks

The process of creating the MATH142 Learninglinks firstly involved identifying resources for each topic, essentially aligning support resources with the topics identified in student lectures or in the case of MATH142 their subject notes. In this case six major topics were identified. These were integration, limit, series and sequences, polar and Taylor coordinates, and application of integration to calculate areas until volume shell. In addition, as revealed in the Math142 Learninglink map accessed in the Australian collection at http://www.equella.com/community/content-without-borders/ resources were also aligned to a total of 28 subtopics.

The identification of resources to support learning over such a wide range of topics is made possible through the work of many educators who have developed mathematics resources, for such topics as required in MATH142, and make them accessible via the internet, for example as videos in Youtube. Some of these video resources are in the type called MathCast (see Figure 5.37), the screen cast of narrated recording of handwritten communication on a computer screen (Loch, Gill, and Croft, 2012, p. C561).

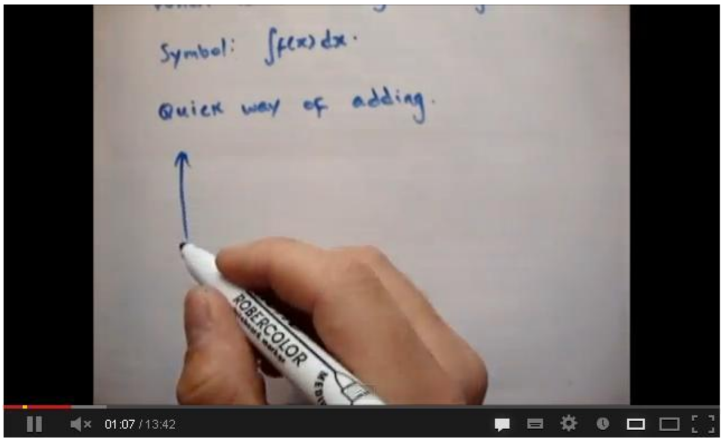


Figure 5.38 An example of MathCast

Due to this availability educators may not need to create new video resources, or may need to do so for only a small number of topics, in order to support their students learning of these topics. There are likely to be adequate videos or resources developed by educators all over the world. In this case around 174 relevant videos for every subtopic were available and in addition another 87 resources in alternative media (PDF, HTML) were used.

Based on the original GRMap system, Math142 Learninglinks allows the mapping of resources but has expanded the functionality to allow the inclusion of images, video clips and equations to be embedded along with a field for explanation of the resource. Math142 Learninglinks has the following features:

1) It provides a map of designated and verified resources accessible via the internet, and allows users to automatically connect to the resources through a button click (no typing of the web address is required)

2) It has the added capability of allowing the map creators to embed pictures or videos into the resource database, to provide a visual image of, for example, the type of worked example demonstrated in the resource.

3) It has the added capability of including mathematics equations in the database (GRMap or in the specific case the Math142 Learninglink Map)

4) Math142 Learninglinks involved development of an additional field allowing up to 255 characters for each field for explanation about resource information.

5.5.2 Using MATH142 Learninglinks

The MATH142 Learninglinks as an embedded learning support system is implemented based on the process, as illustrated in Figure 5.23: 1) MATH142 Learninglinks is stored in an open access collection in EQUELLA, hosted by the University of Wollongong, 2) Students are directed to a compiled version of the map through the learning management system Moodle. Alternatively students can download and install the full package, from the open access collection (via Moodle or the Shareworld Collection), allowing them to further modify the maps of resources, 3) The student optionally uses the MATH142 Learninglinks to facilitate his/her visit to designated and verified resources from his/her lecturer. Future research is needed to determine the best way to implement access and directions for use of the resources.

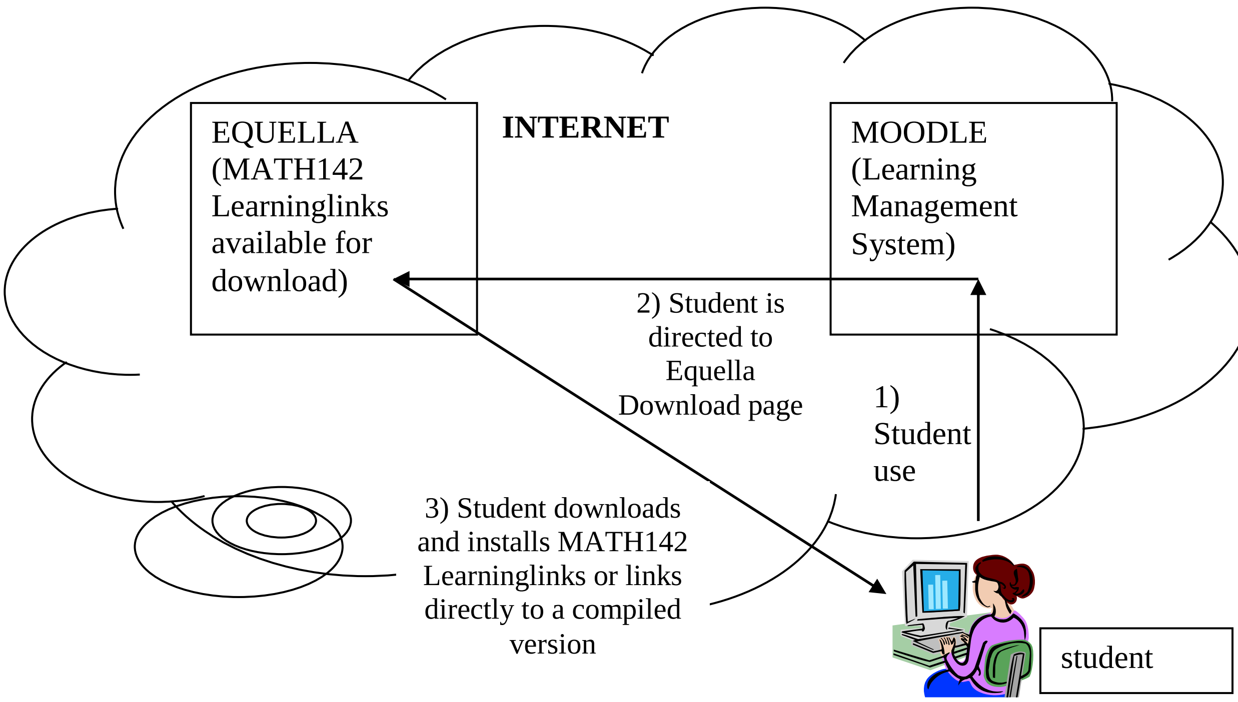
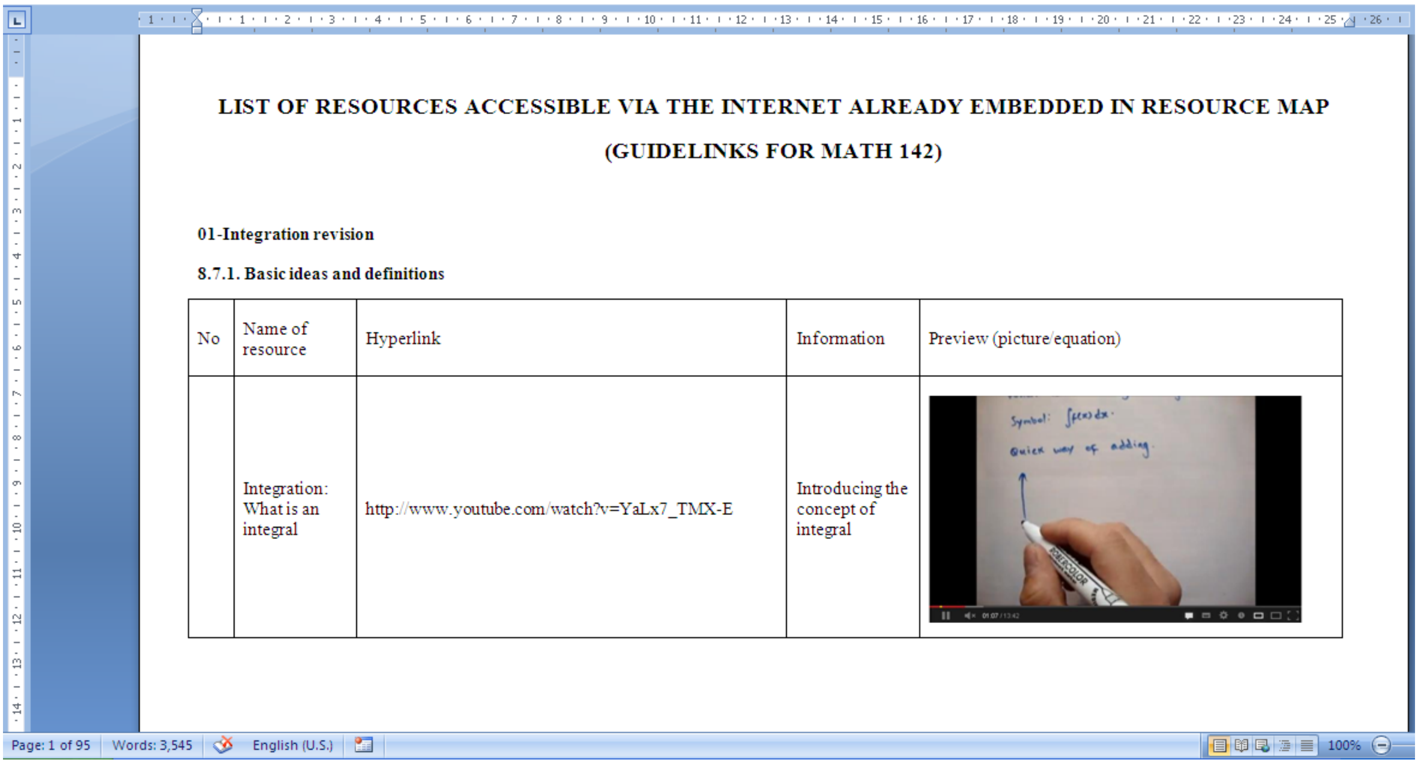


Figure 5.39 Concept of embedded learning support system implementation

Given that there are three operating systems used by students at University of Wollongong, Windows, Mac OS, and Linux and the MATH142 Learninglinks package only can be installed in Windows computer, this option chosen as the most appropriate system for developing countries and an alternative solution is provided for non-PC users. The alternative version for MAC and Linux users involves accessing and using a file of listed resources provided in Microsoft Word file format (refer Figure 5.39). This is a preliminary stage of preparation for the maps of resources. Access to the resources is via the hyperlinks associated with the resources as placed in the document or as cut and pasted to the address bar in a browser. This version has less navigation features, and no button to automatically visit resources, meaning the ease of access and visible structuring of the resources is not as desirable as that provided in the MATH142 Learninglinks map.



LIST OF RESOURCES ACCESSIBLE VIA THE INTERNET ALREADY EMBEDDED IN RESOURCE MAP (GUIDELINKS FOR MATH 142)

01-Integration revision

8.7.1. Basic ideas and definitions

No	Name of resource	Hyperlink	Information	Preview (picture/equation)
	Integration: What is an integral	http://www.youtube.com/watch?v=YaLx7_TMX-E	Introducing the concept of integral	

Figure 5.40 List of resources (MS Word) document

For PC users, access is through either 1) An Access-based application file. To run this file, MS Access has to be installed in the user's computer, or 2) Installation of the complete MATH142 Learninglinks package and documentation (refer Figure 5.41)

1) Access-based application file

This version can run on users computer installed with MS Access 2007 or later. To use this, users simply open the file named eMap_MATH142_2013 using their MS Access software, users are provided with navigation to resources embedded in the electronic maps using associated forms as illustrated in Figure 5.40.

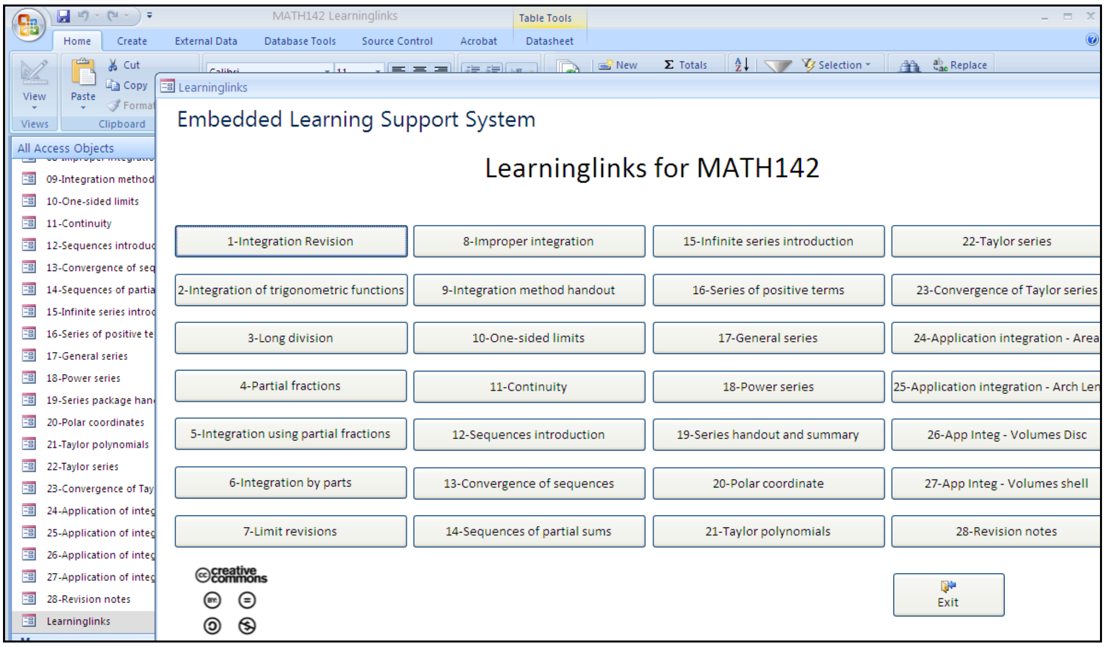


Figure 5.41 Compiled (locked) version of the Access-based application file

2) Installation of the compiled version for use. The files in the MATH142 Learninglinks package are shown in Figure 5.41

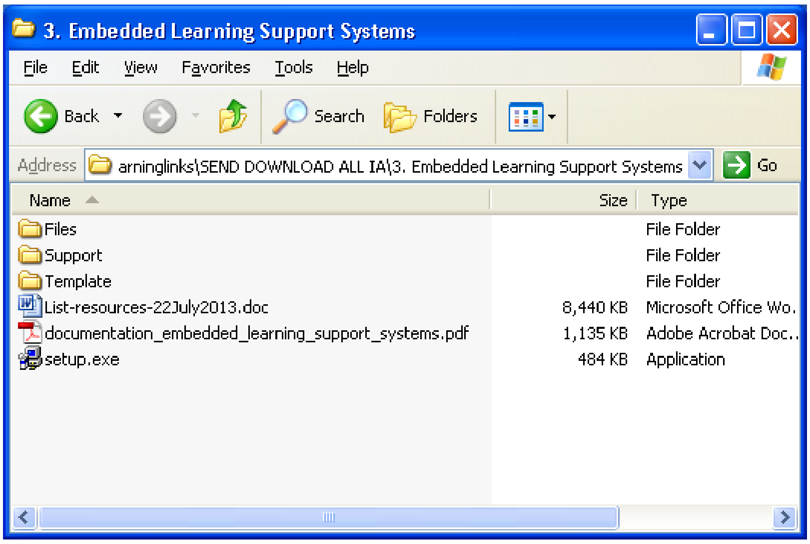


Figure 5.42 List of files in MATH142 Learninglinks package

Installation: users need to install the software application first to their windows-based PC (desktop or laptop) before they can use the MATH142 Learninglinks. The package is available online. Refer to Section 6.4 Dissemination for the download page (at pages 320-321, Figure 6.1)

Following is the process of installation and use:

i. Click the setup to show the installation wizard

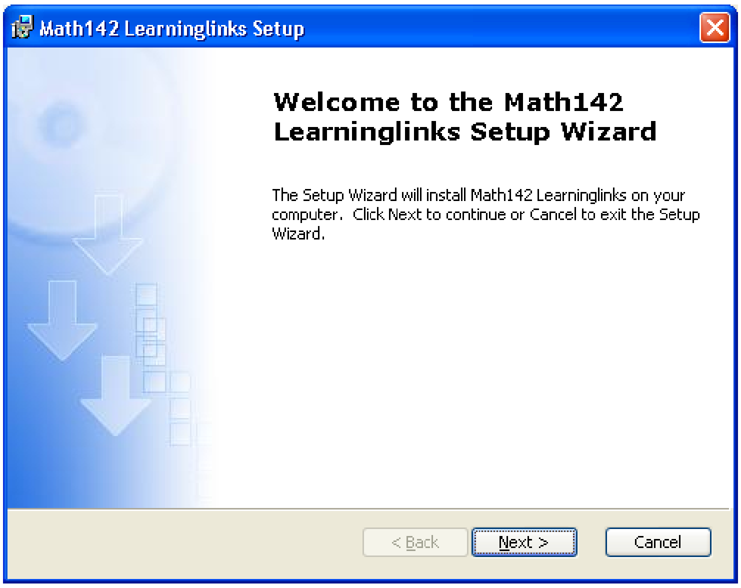


Figure 5.43 Setup Wizard for Guidelinks for MATH142

ii. Follow the setup instructions

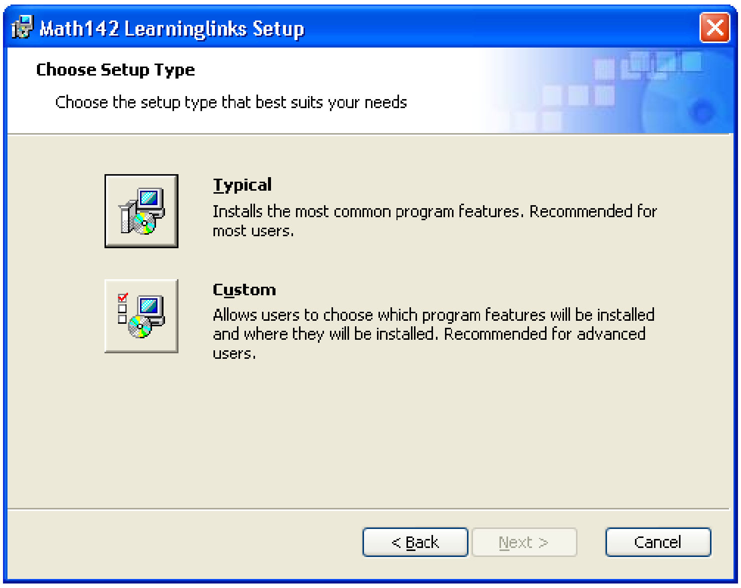


Figure 5.44 Setup types available for installation of MATH142 Learninglinks

iii. The installation may take 3 to 5 minutes, depend on user computer system, until can completed successfully

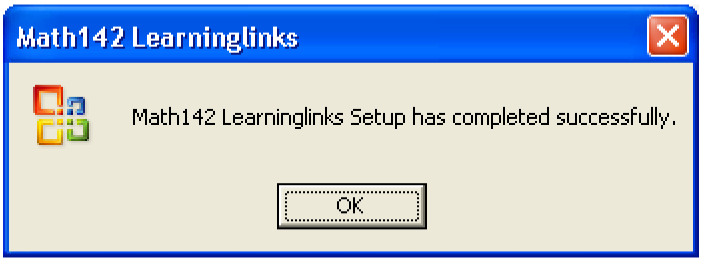


Figure 5.45 Confirmation of successful installation

After the software successfully installed in users computer, shortcuts for MATH142 Learninglinks (with UOW icon) is located on the desktop and in the list of programs available.

Figure 5.46 MATH142 Learninglinks shortcut icon

Use:

i. Click the shortcut to run the application then select the topic from the list (refer Figure 5.46).

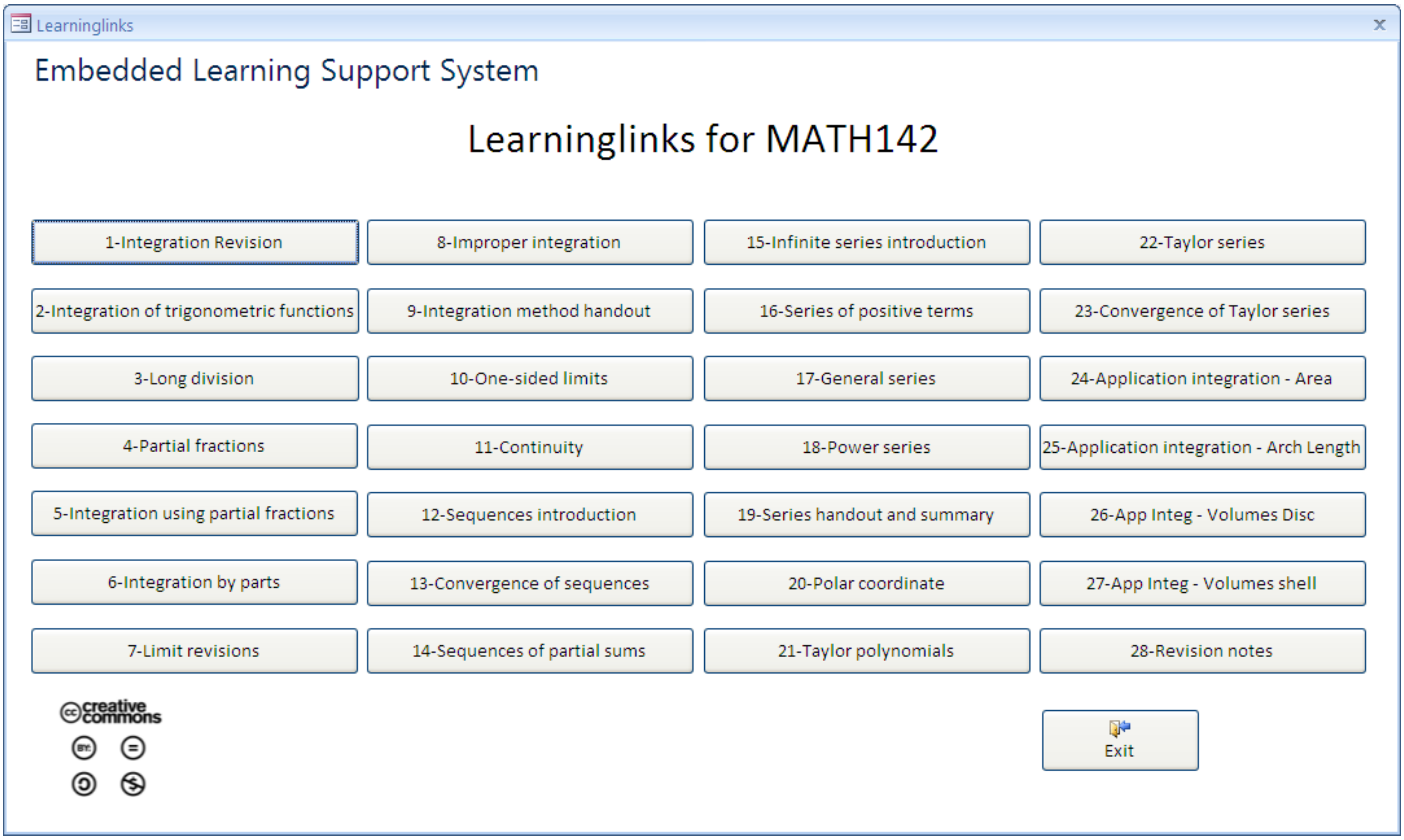


Figure 5.47 Frontpage of embedded learning support system

ii. Browse the available resources database

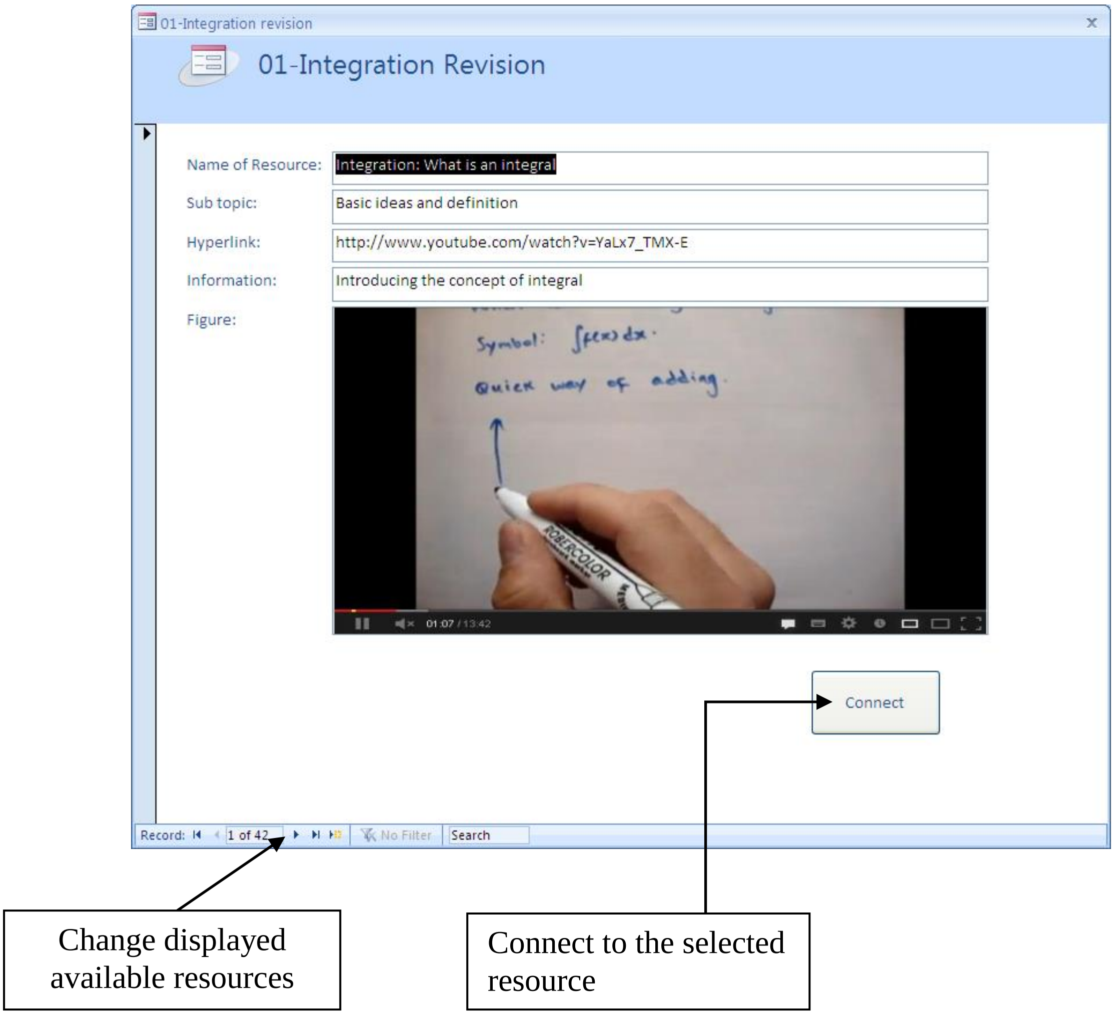


Figure 5.48 Browsing resources

a. Change the displayed resources by using the indicated control

b. Use the Connect button to visit the original location of the resources on the internet

iii. Search in the available resources

In some cases user can search for the specific resources. For that purpose, user can use the search box to type specific term. For example term “worked

examples”. This search function is not case sensitive and searches all fields available in the eMap, MATH142 Learninglinks.

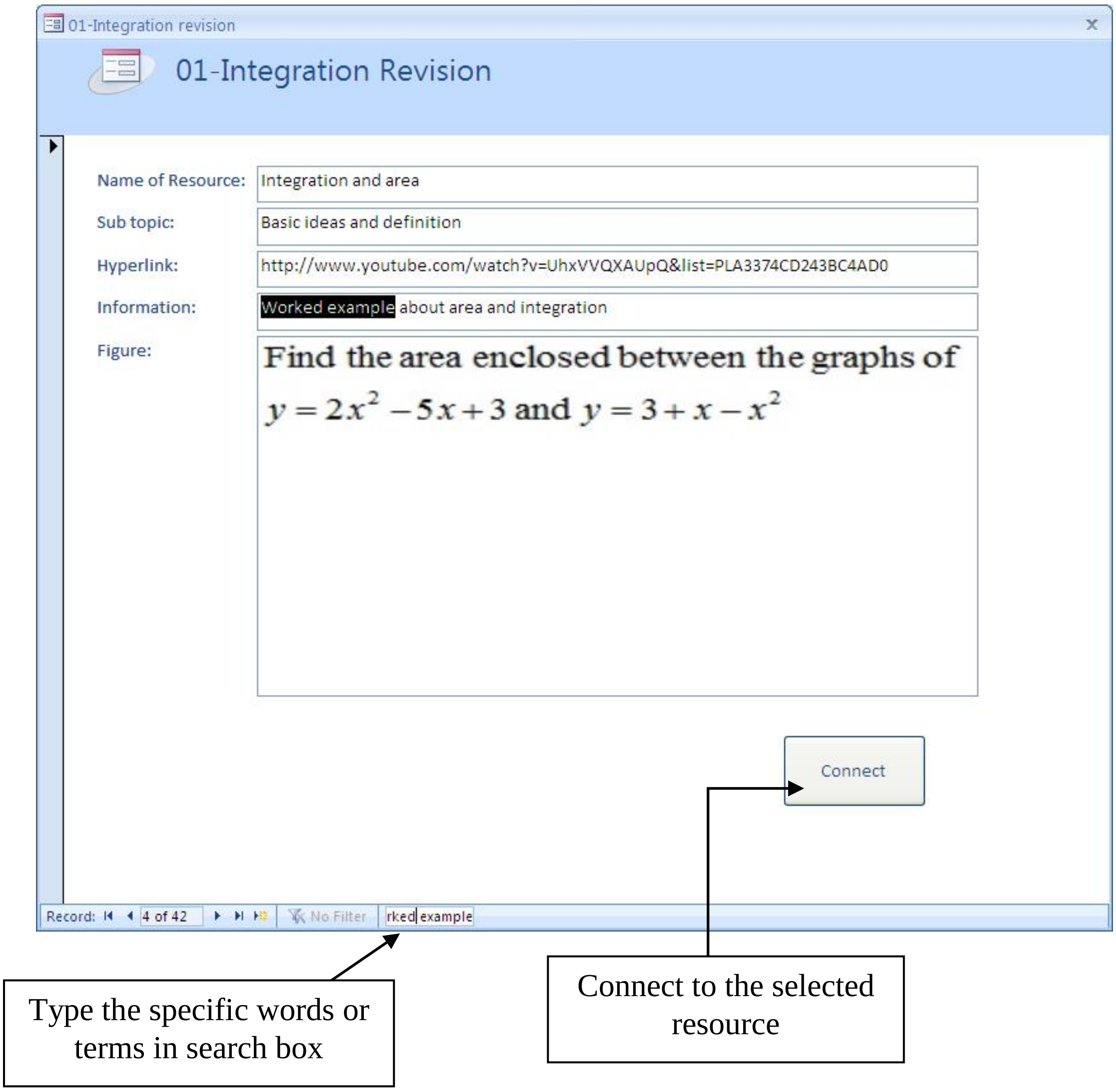


Figure 5.49 Selecting resources

iv. Click the *Connect* button to visit the resource using your own web-browser. After that, user will be automatically connected the selected resource in the internet (as per Figure. 5.50)

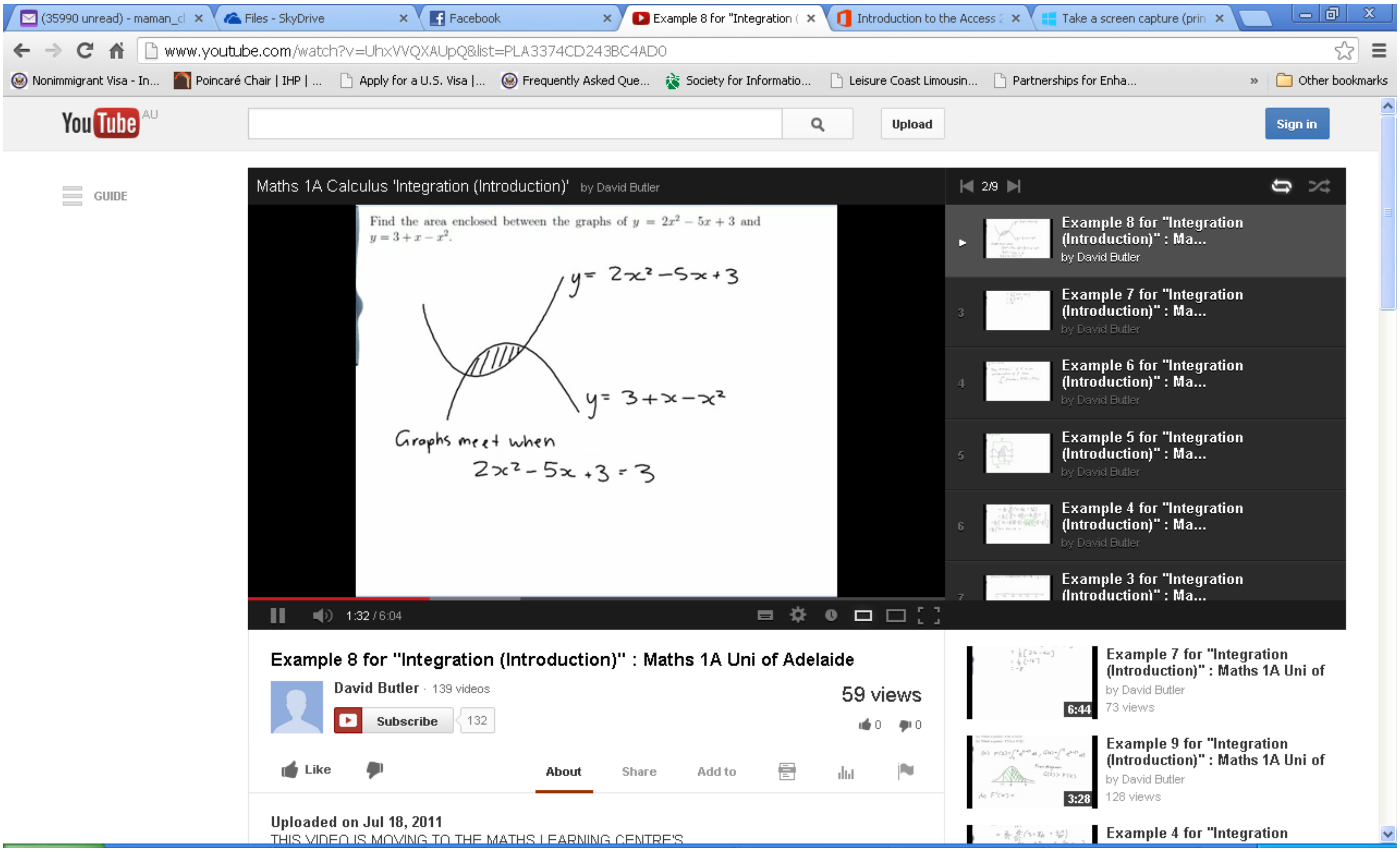


Figure 5.50 Connecting to resources accessible via the internet

5.5.3 Resolution of known problems

Two problems have been identified. Those documented relate to: connection difficulties and screen resolution

1) Connection difficulties. In some cases, users who are using an institutions computer rather than a personal or internet connection, may face error problems when automatically visiting the resources using the connect button. Some institutions, due to security concerns, do not allow automatic connection using hyperlinks. To solve this problem, user can install Microsoft Fixit50655 (provided in the support folder). They need administrator account

to install this support tool. Mac or Linux users need to change proxy of their browser manually.

2) Screen resolution. MATH142 Learninglinks requires 1280 x 800 pixel screen resolution to be showed properly. In the case where the user screen resolution is smaller or larger than 1280 x 800 pixel, the user can maximize or minimize the form (when available) by clicking table icon in the top left drop down menu as illustrated in Figure 5.51.

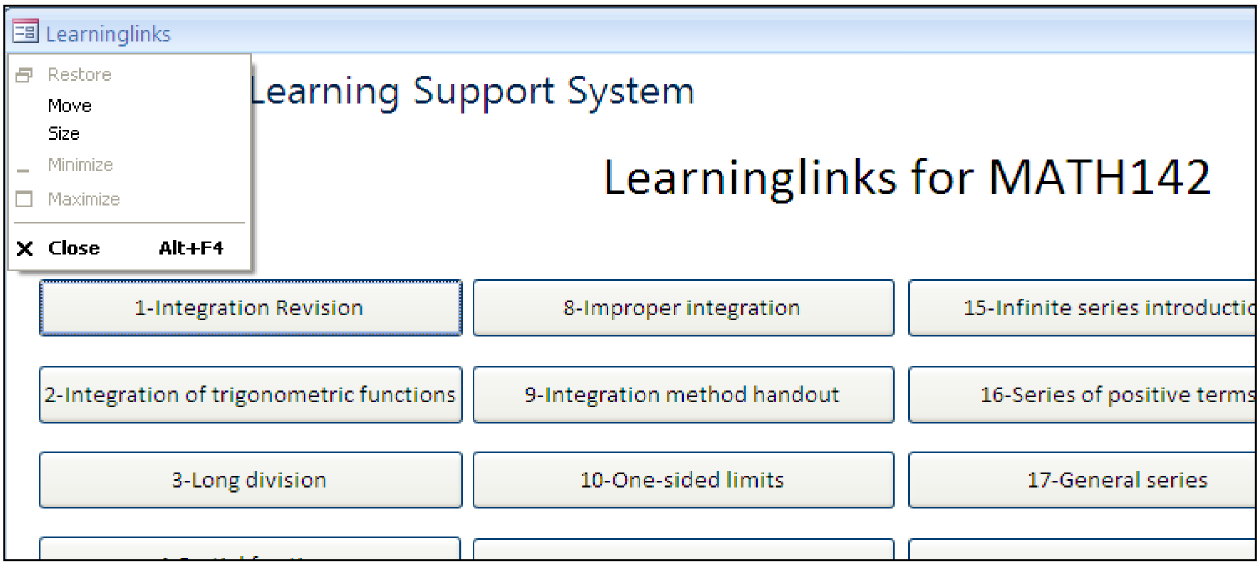


Figure 5.51 Adjusting for screen resolution

5.5.4 Documenting the modification of Learninglinks for MATH142

To enhance the use of any Learninglink map, maps need to be modifiable. MATH142 Learninglinks can represent the starting point for a new map, or a modified map. For example, the Math142 learninglink map is currently being modified to have resources align with similar topics and subtopics in another subject, MATH188 available to a different cohort of students. Modification of the maps involves a number of steps.

1) To be able to modify a map the user will need to obtain a copy of the original electronic map file from the author. This file, typically called eMap template (eMap_MATH142_template) is opened with Microsoft Access or other database viewer such as Open Office (freeware).

2) Select a topic to be modified. In MATH142 Learninglinks, a table represents a topic. Modification or change of contents in a table will result in the change of the learninglinks contents. Adding new tables or removing old tables will result in the addition or removal of topics.

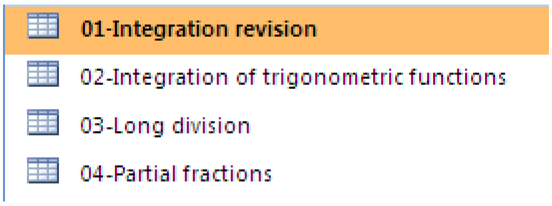


Figure 5.52 Listing of tables for mapping topics

Double clicking on the table image will expand the table (refer Figure 5.53), say for integration to show all subtopics.

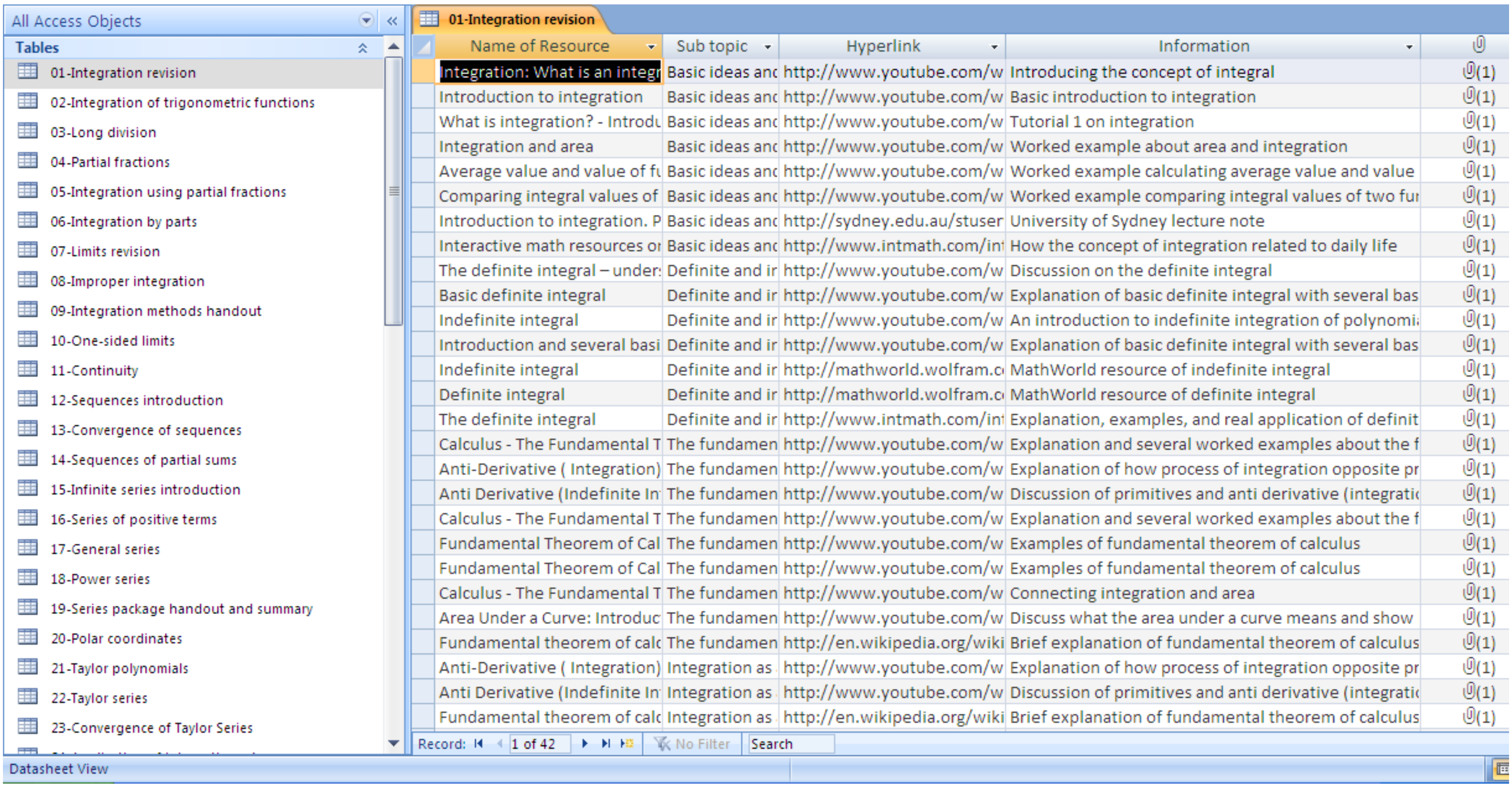


Figure 5.53 Table for subtopics in Revision of Integration

3) Modifying contents of existing tables (without removal or addition of topics)

To modify contents (name of resource, subtopic, information or hyperlink) viewable in the expanded table, the user needs to type or replace the original data with the new data, or attach pictures or equations to the appropriate fields.

4) Add or remove tables (topics) of mapping

If user wants to add or remove a table (that is a topic), an existing table can be copied or removed.

- Copying or deleting a table: With a table selected (refer Figure 5.53) the menu can be accessed and copy or delete selected.

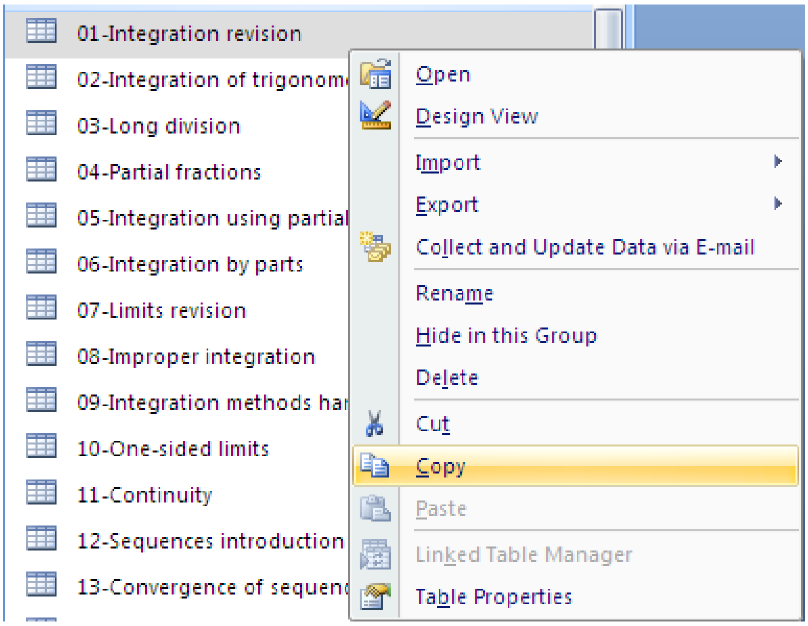


Figure 5.54 Process of copying or removing tables

- Pasting: After copying a table, it may be pasted with or without contents (data) of the original table (refer Figure 5.55).

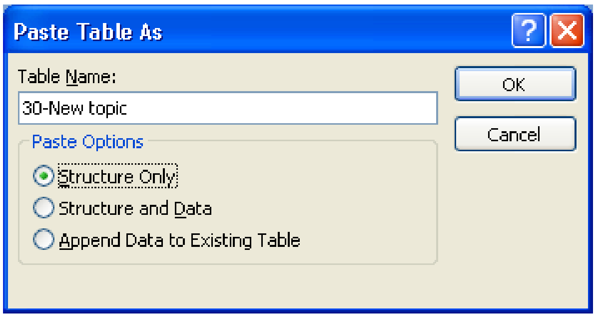


Figure 5.55 Option in copying tables with or without existing data

- Adding an associated form. After adding a new table, a user will need to add an associated form to this table (refer Figure 5.56) so that a new form to display table will be appear.

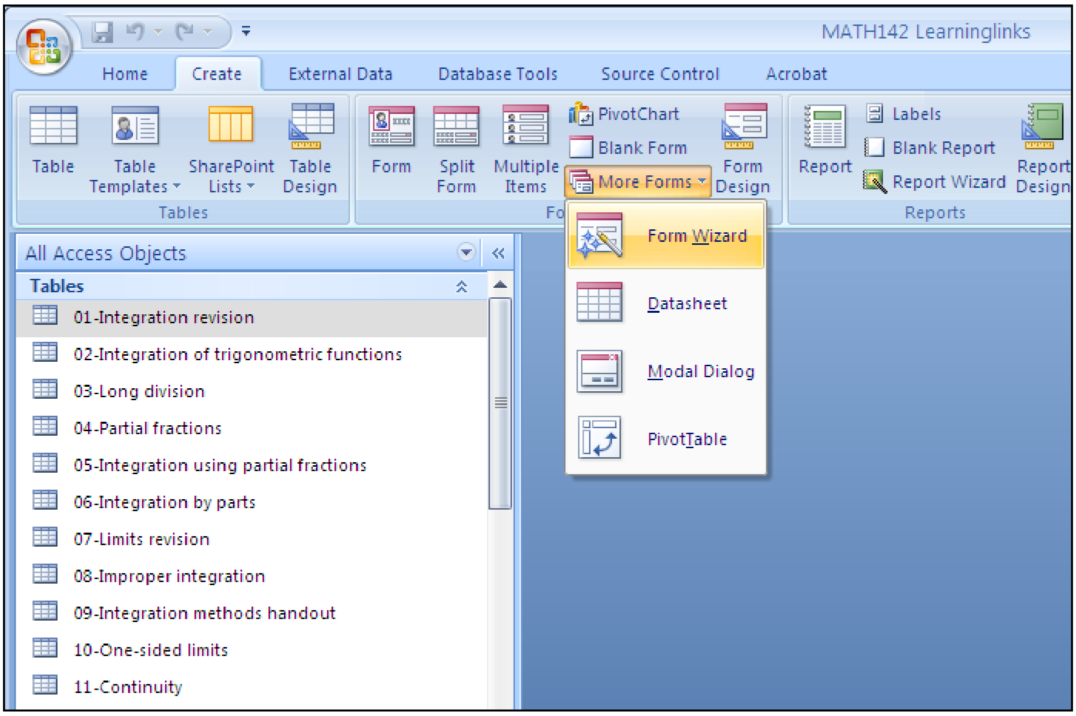


Figure 5.56 Adding a form

- Connect the table to the form as in Figure 5.57 so that contents of the associated table can be displayed in this form

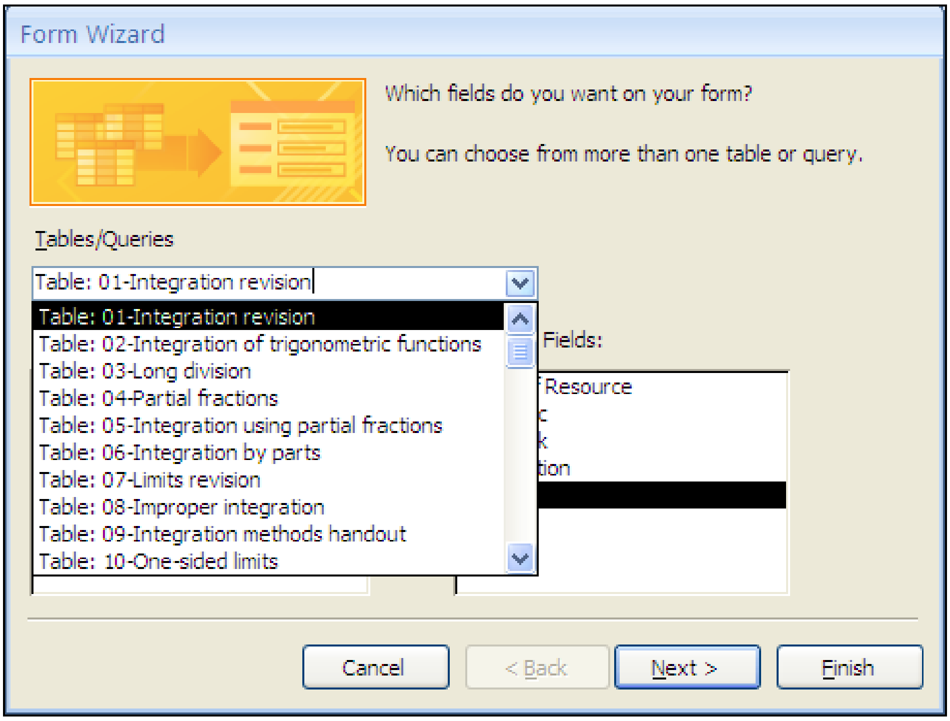


Figure 5.57 Connecting new added form to a table

5) Sharing and Modifying Learninglinks

The User can share the modified electronic maps with others by creating installation package using *Microsoft Access Developer Extension (free)* by following the instructions:

a) Lock electronic maps (if needed) to keep the structure of database, then save to a specific folder

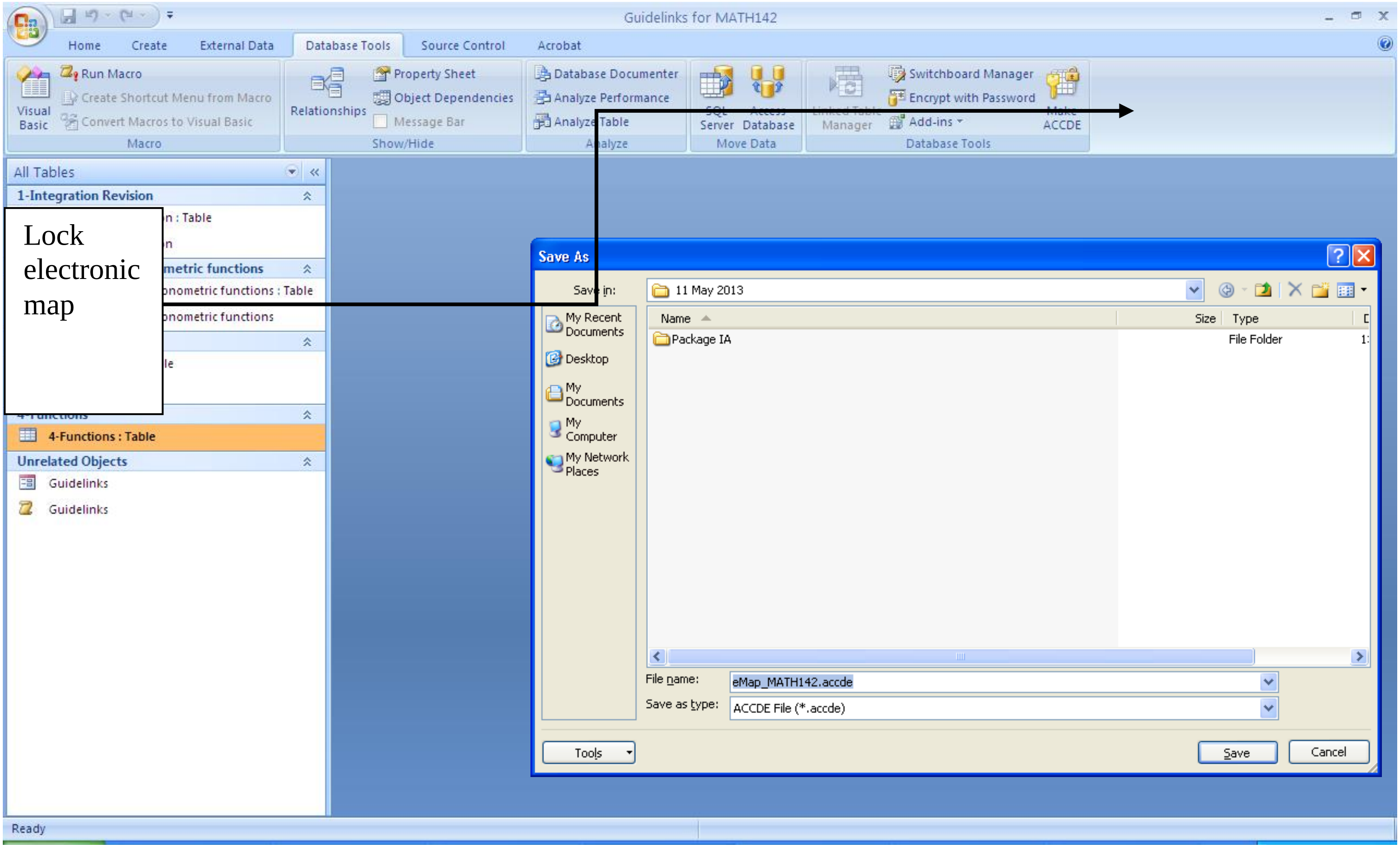


Figure 5.58 Locking resources map

b) Install Microsoft Access Developer Extension if not already installed

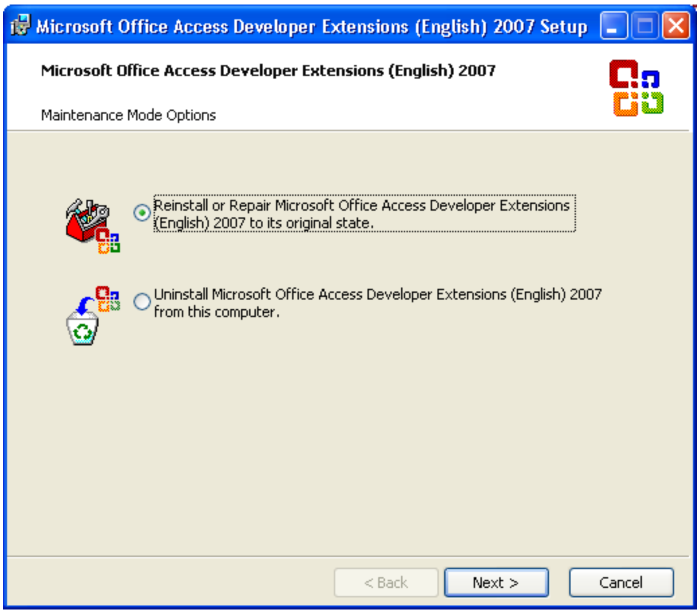


Figure 5.59 Installation Wizard for Access Developer Extension

c) Use Developer > Package Solution to create an installer package

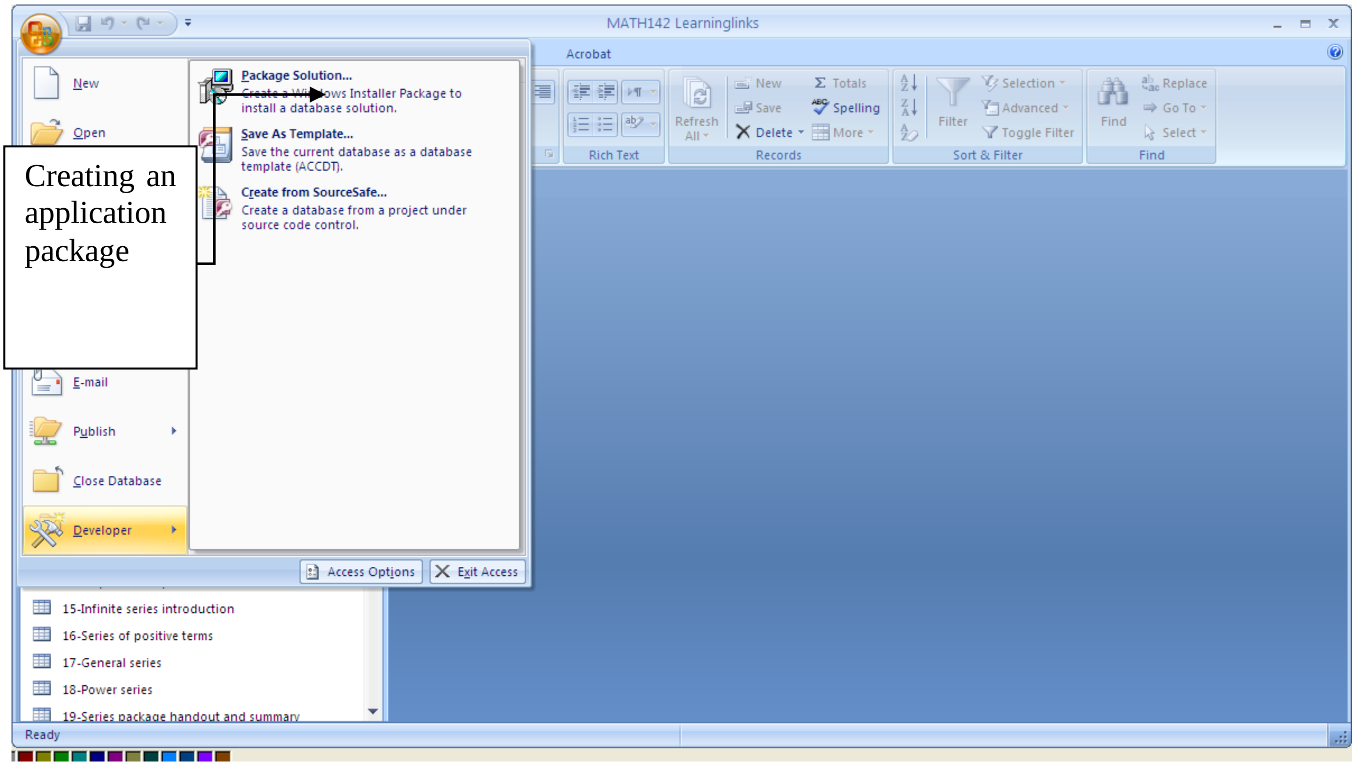


Figure 5.60 Packaging resources map for sharing

d) Follow the instruction, and add *Access Run Time* (free) to make sure that the user will be able to use the application without Microsoft Access installed in their computer.

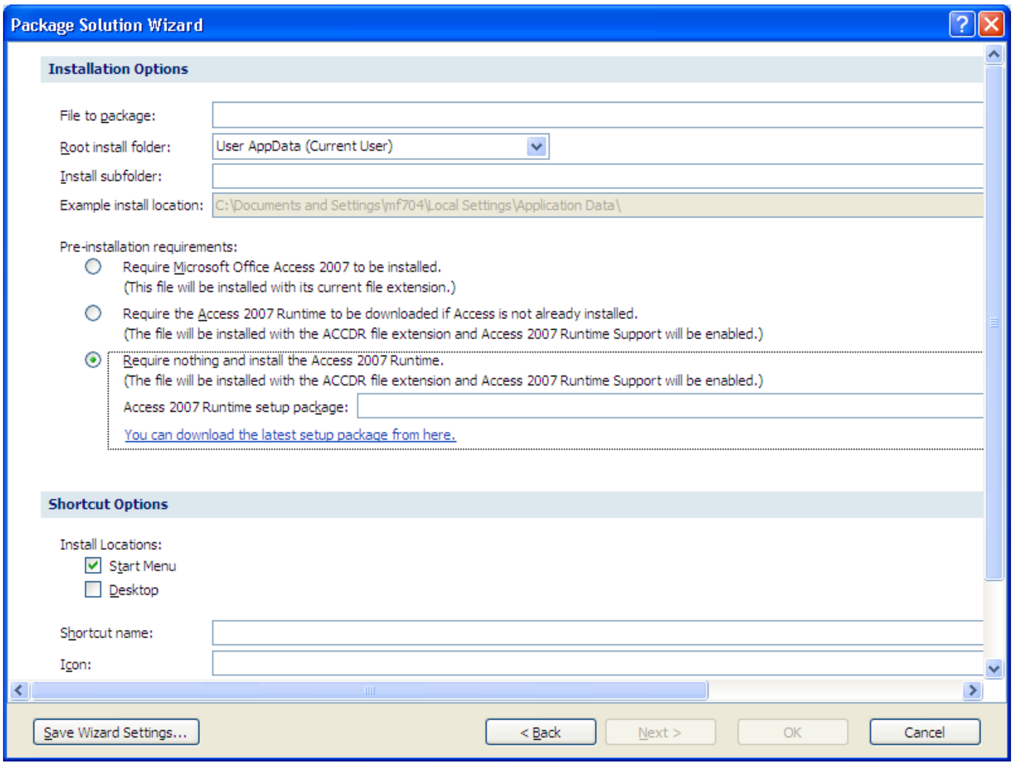


Figure 5.61 Package wizard

e) After that, the modified learninglinks (application package, similar to Figure 5.41) will be ready to share via internet, CD/DVD, or USB thumb drive.

5.6 Documentation

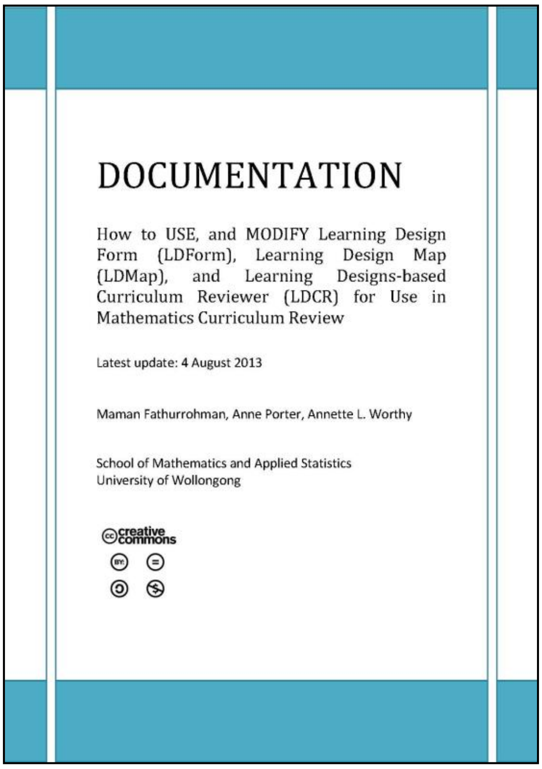
Throughout the exploration with curriculum mapping and the establishment of an embedded mathematics learning system for MATH142, the issue of modifiability was raised. Those who were interviewed had used tools for mapping and review which were in some ways deficient for example in the ability to add a new set of

graduate attributes, or to modify the existing system of tools to adapt to the needs of another institution. The lack of documentation to guide users from other external organizations to know how to modify the system was problematic. In this adaptation of use to create embedded learning support issues such as the ability to include a picture as well as text into the map of resources and another field of information were raised.

To address the issues of modifiability two approaches were adopted 1) The provision of documentation and 2) The testing of that documentation.

5.6.1 Provision of documentation

Following are covers of the documentations. This documentation is embedded in the associated tools as PDF files.



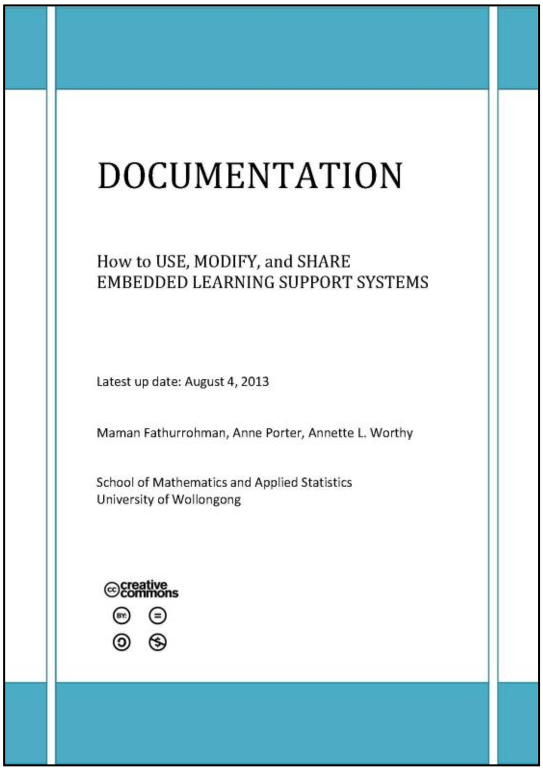


Figure 5.62 Covers of documentation

The emphasis in the documentation is the explanation of how to use, modify and share the tools. By providing documentation, it is likely that many people can be guided to make contribution, either by further development of the tools or by expanding the use of these tools to other tasks.

5.6.2 Testing of documentation

To examine modifiability from this perspective, the complete set of documentation and software was provided to a lecturer from Universiti Teknologi Mara (UiTM), Malaysia, who was visiting fellow at University of Wollongong, National Instutitue for Applied Statistics Research (NIASRA), and a graduate student from Libya, with the task of adding new resources and modifying the existing tool to see if they could use, modify and share, the tools to suit their purposes.

Following is their comments after testing the software and documentation:

> *"Generally, the development of eMap [of] Learning Resources for Mathematics is brilliant. This is an innovative way of bringing internet resources to your doorstep. It cuts down the search and browsing time and allow the users to view learning resources that is only most appropriate for the subject" (Visiting fellow)*
>
> *It is good tool for learning resources and any subjects can use in it not just math. Teacher and student can share the same information by easy way"(Graduate student)*

The supervisor of this thesis also explored the MATH142 Learninglinks checking that she could follow all documentation before approving release of the MATH142 Learninglink package and documentation. Based on these reviews, the documentation provided appears adequate for users and developers of embedded support learninglinks. The software can help lecturers and students to easily access internet resources, cuts down the search and browsing time, and guides them to the

designated resources appropiate for the subject, importantly the resources are aligned with all topics covered in the subject The use of electronic maps enables lecturers and students to use share the same information by easy way.

In regard to modifiablity, the visiting fellow stated the following:

> *"The Guidelink enables the user to use and modify the tables and contents very easily. This should appeal more to the users as it gives them more flexibility to create and modify the contents and tables according to the course content/syllabus" (Visiting fellow)*

While for the shareability:

> *"This is the most desirable feature where Guidelinks can be shared with unlimited number of users using several easy to follow procedures".(Visiting fellow)*

Both statements emphasized that electronic maps are modifable and flexible for use by users. This ability to modify and share maps as illustrated in documentation is important when one considers institutionalization of the electronic maps. Maps for MATH142 has been developed and available for student use in Spring 2013 and under modification for a second subject, MATH188. A map with a new set of resources is currently under development for tri-lateral use in Indonesia, Malaysia and Austalia, based on STAT131, an introductory statistics subject at UOW. Through adapting the electronic maps to other course subjects and requirements for their course content or syllabii, and also to satisfy the user (lecturers and students) needs the tools are being institutionalised. That said to map an entire set of resources for a subject such as MATH142 involves subtantial effort. The time to locate, verify and to add resources to the map was approximately one hour per subtopic, which consists of nine resources (three videos of lectures, three videos of worked examples, and three other (for example PDF, HTML, resources). The time however to modify the map for a second subject, in case for similar sub topics, to modify (add or

remove) the contents, and embedded additional for subtopics was far easier, taking approximately only 10 to 20 minutes per sub topic.

As stated by the visiting fellow, she intends to use the electronic maps for mapping statistics subjects resources accessible on the internet for not only Mara (UiTM), Malaysia

> *"Yes, I do have plans to implement Guidelinks for several postgraduate statistics subjects at my university [in Malaysia]"*

While she also provide feedback for improvement as following:

> *"Perhaps, the content can be enhanced using different colour text to represent each topic. This would enable the user to search and identify certain topic of interest easily"*

The software package titled MATH142 Learninglinks and its associated documentation of mapping tools for mathematics have been stored in the University of Wollongong (UOW) Shareworld collection and are available worldwide through Content without Borders, the Australian collection, available at http://www.equella.com/community/content-without-borders/. The package is made available under a Creative Commons license version 3.0 AU (CC BY-NC-SA), which means BY (recognizing researchers as the author of the technology-based tool), NC(Non Commercial use), and SA (Share-alike). This license allows mathematics teachers and lecturers all over the world to use, modify and share the electronic mapping system and through this the package is readily available for dissemination. People will be able use and modify both GRMap (used for Math142 Learning Links) and LDMap for mapping teaching and learning. These activities have contributed to improving the usability of electronic mapping system since it was first trialled in Bojonegara Subdistrict, Banten Province, Indonesia.

5.7 Future development

While the number of case studies was small, in regard to future development, as revealed by Table 5.31, 76.9 percent of participants strongly agree, the tool has a good prospect for use in other developing countries. Furthermore, 61.5 percent also strongly agree that in the future, the electronic mapping systems has a good prospect for use in developed countries and for use in other subjects (not only in mathematics).

Table 5.31Teachers' Evaluation of the tools in regard to future development

No	Aspects	Evaluation					
		Strongly Agree		Agree		Neutral to Strongly Disagree	
		Count	%	Count	%	Count	%
1	Future Development						
	a) Tools could be used in developing countries	10	76.9	3	23.1	0	0.0
	b) Tools could be used in developed countries.	8	61.5	5	38.5	0	0.0
	c) Tools could be used in other subjects (not only in mathematics).	8	61.5	5	38.5	0	0.0
	d) Tools have a good prospect for patent and commercialization	8	61.5	5	38.5	0	0.0
	e) Tools are recommended to be available in other platforms (not only for Windows operating system)	5	38.5	8	61.5	0	0.0

Future directions for the three areas electronic mapping system development, the original software, curriculum review tools and embedded mathematics learning support have been identified.

5.7.1 Electronic mapping systems

As a consequence of teachers' evaluation results (refer Table 5.31) a focus was made on broadening and improving usability of the tools. The electronic mapping system, consists of GRMap and its associate reader (Guidelinks), and LDMap and its associate reader (LDSoft). The GRMap which produced MATH142 Learninglinks

can be further extended, not only for use in teaching and learning of mathematics, but also for use in teaching and learning of other disciplines. One of the most feasible and achievable uses is the implementation of the electronic mapping system for use in STEM (Science, Technology, Engineering, and Mathematics) teaching and learning. Furthermore the spread and usability of the tool can be leveraged by providing this electronic mapping system not only for teachers in developing countries, but also for use by educators in developed countries.

For future work, professional programmers can work together with researcher to develop software and application based on the electronic mapping system's concept. The hiring of professional programmers is important, to access programming capabilities, to help develop the applications for use in emerging and widely used operating systems and platforms, such as Mac, iOS, Android Tablets, and Web-based applications, including enabling of putting electronic maps in the clouds for easy access by users by considering standards (Waschke, 2012) of the widely spread cloud technology.

5.7.2 Curriculum review tools

Three extensions are likely for the curriculum review tools that combine the subject LDmaps created through LDForms to generate output to review the subject. These extensions are making tools compatible for different system, extension to other disciplines and institution defined curriculum reviewers.

1) Different systems

Cross platform use is highly desirable wherever communities use different tools. Applications for the iPad and Android Tablet based on Learning Design-based Curriculum Reviewer (LDCR)' concept can be developed. Currently LDCR is based on an Excel file, which may make lecturers/teachers as for example one interviewed in Australia reluctant to use it. So the development for these

alternative platforms is important. This would allow users to use their own iPad or Tablet to analyse one or more LDMaps in curriculum review activities.

2) Extension to other disciplines

These tools are particularly suited to disciplines that use a classification of topics taught, such as physics. Physics has an available physics subjects' classification, similar to mathematics subjects' classification that can be used for curriculum review. Further investigation of ways to include two levels of topics – topic and aligned subtopics will improve use particularly when finer detail is required to examine say if pre-requisite skills have been taught for later subjects.

3) Formal institution curriculum review

The future development of web-based application of LDCR to read and analyse LDMaps is relevant with trends and the need for web-based application curriculum mapping software (Oliver, Fern, Whelan, Lilly, 2010). It is also possible that in the future a formal institution-based curriculum reviewer, a web-based application, be developed to analyse LDMaps. This tool may be more suitable for large institutions, and institutions in developed countries than the current tools where maps require manual distribution and are likely to involve dispersed rather than centralised storage.

5.7.3 Embedded mathematics learning support

In relation to embedded learning support system, called Learninglinks (developed from GRMap), it is also licensed under a Creative Commons license version 3.0 AU (CC BY-NC-SA). MATH142 Learninglinks enables lecturers/teachers, and their students to access an embedded learning support system to visit the designated and verified resources accessible via the internet easily. In practice, this system can be

considered as in early stage of design and development. Many improvements can be made to improve functionality and expand benefit of this product. The proposed practical improvement for future development is as following:

1) Availability of Learninglinks for Mac OS

Many people particularly in developed countries have Mac OS as primary computer operating system for their home and office, including in educational institutions. The availability of Learninglinks for this operating system will benefit them thus enlarging the potential users of Learninglinks and importantly allow institutions where dual platform is common to equitably provide support for all students.

2) Availability of Learninglinks for iPad and Android Tablet

A unique feature of Learninglinks involves visiting resources without typing a web address, this feature should to be useful for people using the iPad and Tablet. While using iPad and Tablet, users are confronted with more difficult use if they are to type web addresses using its virtual keyboard. Accessing internet resources through using the button click approach Learninglinks is expected to be useful for users of these devices.

3) Technical improvement

Two key technical improvements to enhance the current version of *Learninglinks* have been identified.

1. Re-arrangement of the buttons in main form such as in Figure 5.62. This re-arrangement of buttons may improve visual appearance and usability of this form.

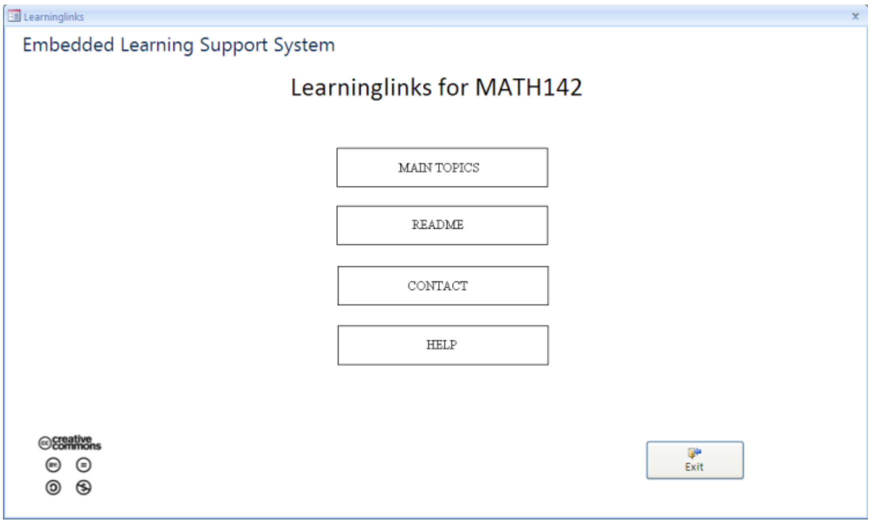


Figure 5.63 Sketch of future main form of Learninglinks

2). Enhancing navigation feature.

Enhancing navigation feature (refer Figure 5.64) will make users easier to navigate between topics and subtopics. Adding new tab will help users to locate subtopics in a glance and allow easy linking to the subtopics rather than using the arrows to move one at a time through an invisible listing of subtopic resources.

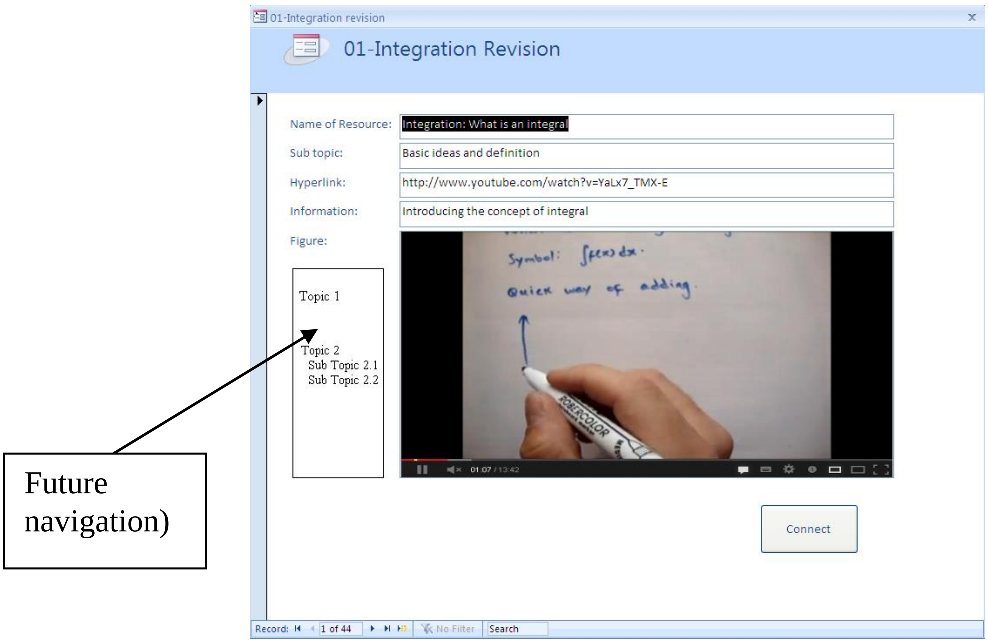


Figure 5.64 Sketch of future navigation of Learninglinks

Along with these changes there needs to be an upgrade path that allows users to update their existing Learninglinks, for example for MATH412 without requiring re-entry of the resource information.

There is no end to the development of software, just an interim stopping place, a release before development continues. So it is with the development of LDMap, the release of a useful set of tools has been created for teachers.

CHAPTER 6. CONCLUSION

This chapter is framed in terms of concluding remarks regarding the research results. The Alexander and Hedberg evaluation model is revisited, to ensure that all necessary research and evaluation has been completed. The dissemination of the software tools, research achievements, and how these achievements address the research questions are discussed. The chapter concludes with recommendations with respect to future research directions.

In this final phase of the thesis the original aims and research questions are revisited, the process in terms of an overview of what was undertaken from the Alexander and Hedberg's (1994) model of evaluation is provided, software and findings and their dissemination are discussed, and concluding remarks and recommendations are proposed.

6.1 Aims

The broad aim of this study was to identify ways to improve mathematics education while at the same time reducing the digital divide in developing countries, especially in Indonesia, by introducing and providing technology-based tools for use by teachers. Use of technology is an important component of developing readiness and reducing lack of knowledge and improving skills for closing the digital divide.

The process to address these aims included collecting data to address several research questions:

1) What access to information and communication technologies do mathematics teachers in developing countries, and specifically in Indonesia, have to facilitate teaching and learning?

2) Given the level of technology available how can mathematics teachers in developing countries be supported in the introduction of technology to the mathematics classroom?

Initially the focus on developing tools was to map and share mathematical learning resources and learning designs, leading to the question:

3) In what ways can the introduction and provision of technology-based mapping tools for learning designs and resources contribute to improving mathematics education in developing countries and specifically Indonesia?

The software tools were trialled in Indonesia but the need to improve usability of the tools involved an exploration of use in Western cultures as the question arose:

4) In what ways can the technology-based mathematical learning resource and learning design tools be improved to be more usable and sustainable?

Improving usability involved expanding the uses to which the tools could be applied as well as the functionality and modifiability of each mapping tool, hence the following questions were posed:

5) Is there a difference in student learning outcomes when comparing traditional teaching to learning through the use of technology in resource-based learning?

6) How can the mapping of learning designs facilitate the mapping of curriculum?

7) What is required for the mapping of resources be used to create embedded mathematics learning support systems?

6.2 Evaluation, revisited

The Alexander and Hedberg model (1994) for evaluation of innovation involved evaluation at four stages: design, development, implementation and institutionalisation. In this thesis, this process was iterative with follow-up work refining and evaluating the original software tools in terms of further needs that were identified. For successful innovation evaluation needs to take place at each stage. The four stages of evaluation were addressed through a sequence of studies addressing the questions posed, sometimes addressing more than one stage in the evaluation process as summarised in Table 6.1

Table 6.1 Iterative stages of evaluations

Stage	Study	Use
Design	Localised study 119 teachers with questionnaire and 12 teacher interviews	Identified needs of teachers in a developing country and the facilities available for teachers and students to use tools developed
Development	Design and development	Development of tools to map resources and learning designs as identified in the localised study and coded using Visual Basic
Implementation	Case studies of 13 mathematics teachers	Established usefulness of the software in terms of teachers sharing mathematical learning resources and learning designs
Institutionalisation	As above case study of 13 mathematics teachers	Identified teachers' positive perspectives as to future use of tools
Design	As above case study of 13 mathematics teachers	Identified a need to improve usability
Re-design, development, and Institutionalisation	Improving usability, as follows:	The usability of the tools was expanded by developing additional functionality and demonstrating new uses
	1) Hyperlearning	Experiment conducted on students use of technology-based resource-based learning
	2) Alignment to Indonesian national curriculum	Demonstrated concept of alignment of resources and learning design maps to national curriculum
	3) Curriculum review	Expanded usability to include curriculum review capability
	4) Learninglinks	Demonstrated use, through the creation of a map of learning support resources for MATH142. Revisions for MATH188, New tri-nation version under creation for introductory statistics
	5) Documentation	Improved documentation for three packages (Electronic Mapping System, Curriculum Reviewer tools, and Embedded Learning Support System) and tested this with reviewers. Documentation provided in English and Bahasa.

Within this overall evaluation framework, the software has been continuously improved based on feedback received, and the original electronic mapping system evolved from the original to an extended version catering for Curriculum Review and Embedded Learning Support System (refer Table 6.2)

Table 6.2 Relation between tools developed during the research project

<table>
<tr><td></td><td colspan="3">Electronic Mapping System</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Original

(Section 4.2)</td><td colspan="2">Expansion</td></tr>
<tr><td>Curriculum Review
(Section 5.4)</td><td>Embedded Learning Support System
(Section 5.5)</td></tr>
<tr><td rowspan="2">Mapping resources</td><td>GRMap</td><td rowspan="2"></td><td rowspan="2">MATH142 Learninglink

Additional functions:
• Import of images and files,
• Enable inclusion of equations
• English language in addition to Indonesian language.</td></tr>
<tr><td>Guidelinks
(Associate reader of GRMap)</td></tr>
<tr><td rowspan="3">Mapping learning designs</td><td rowspan="2">LDMap</td><td>Modified LDMap

Additional functions:
• Additional fields added
• Different types of fields (Graduate qualities, Mathematics subject classifications)</td><td rowspan="3"></td></tr>
<tr><td>LDCR

Additional tool to analyse all LDMaps together automatically for curriculum review</td></tr>
<tr><td>LDSoft
(Associate reader of LDMap)</td><td>LDForm
(Excel-based version of LDSoft)
Additional tool to capture learning design then convert the data to LDMap

Additional functions:
• Additional fields added
• New fields added (Graduate qualities, Mathematics subject classifications)
• Ability to print out modifiable subject outline templates</td></tr>
</table>

Throughout the evaluation process, it is acknowledge that due to lack of financial support, time and researcher capability, the study has limitations on the following parts: (1) small number of 13 mathematics teachers participated in the case studies, and (2) the field work was conducted only in one accessible area in a developing country. Despite of this limitation, it is hoped that the results still reflect the aims of introducing and providing technology-based tools for use by teachers to improve mathematics education.

During the study many challenges were faced by researcher, such as: (1) difficulty in visiting some observed schools during localized study of ICT condition, due its remote location, (2) technical difficulty in programming the software using visual basic, (3) limitation of mathematics teachers time to engage in case study, (4) several unexpected incidents such as students protest against high frequency test schedules in the hyperlearning empirical study, and collecting real data regarding courses for the curriculum review. To address the challenges, researcher (1) request help from brother, and senior head master to accompany researcher in visiting some schools, (2) expanding researcher knowledge about software programming, then designing tools based on researcher capability, (3) consultancy with senior head master about the right time to visit teachers, then liaise to develop a schedule with them, and (4) adapting the researcher's study to the practical condition of empirical study and curriculum review.

6.3 Findings

When examining the questions regarding what access teachers had to information technologies to facilitate teaching and learning and the support that they required to introduce technology into the mathematics classroom it was determined that teachers in developing countries are able to operate computers and other ICT-based tools. While the ICT infrastructure, facilities and resources in their schools or area is generally poor, teachers and students often access and use through personal resources.

It was found that mathematics teachers in developing countries can be supported in the introduction of technology by providing ICT-based tools. In this case the software tools considered by teachers as the way appropriate to further mathematics education were for mapping and sharing resources and learning designs. Case studies conducted with 13 mathematics teachers evaluated the implementation of the tools in Indonesia suggested that the involved teachers were satisfied with the products' components. The teachers found the tools appropriate, given accessible ICT infrastructure and appropriate for use by mathematics teachers and further that these prototypes are appropriate for use by teachers for sharing mathematical learning resources and learning designs. Mathematics teachers agreed that the prospects for implementation, impact, and sustainability of the use of the tools by teachers in the long term were good. This boded well for being able to embed the tools at an institutional level, rather than the one-off use by individual teachers, however the usability aspects of the tools while positive with all teachers, was less satisfactory than other aspects, such as the idea and innovation. This initiated a second phase of work on the usability of the tools.

In terms of institutionalisation, to have the tools adopted and used by others outside the province of the study, it was considered important to enhance usability in terms of expanding the range of uses for the tools, refining the tools, adding functionality to make the tools more usable and improving the documentation. One step in this process was to make the electronic mapping system is available in both Bahasa, the Indonesian language, the native language of country focus of this study, and English, the universal language used by many nations in the world. This explication of uses to enhance prospects for institutionalization of the tools included extending its potential use through demonstration that the mapping system could be used as a teaching methodology providing the opportunity for students to learn through Guided Hyperlearning (refer Section 5.2). In addition the conceptual aspects for mapping and aligning and mapping resources and learning designs for the Indonesian national curriculum (refer Section 5.3) were demonstrated. The mapping tools were further refined and a Learning Design Form to capture learning design data then convert it to a Subject Information Sheet and to a LDMap A Learning Design-based Curriculum

Reviewer (LDCR) tool to analyse multiple LDMaps was developed and used to demonstrate the conduct of a curriculum review (refer Section 5.4). Further exploration of uses involved developing additional functionality to create an embedded learning support system, Learninglinks (refer Section 5.5) allowing students to access mapped and verified learning resources. Finally addressing the needs of different institutions and users to be able to modify the tools, to address their specific or changing needs documentation was provided and tested (refer Section 5.6). These improvements further enhance the prospects of use by teachers and institutions, contributing to the improvement in usability of electronic mapping system since it was first trialled in Bojonegara Subdistrict, Banten Province, Indonesia. Expanding the tools functionality, modifiability and usefulness are likely to lead to an expanded culture of use and through this in the terms of Alexander and Hedberg's evaluation model (1994) better institutionalisation or embedding of the tools into ongoing institutional use.

6.4 Implication to policy makers

Policy makers, from the heads of schools to the head of the education office in Bojonegara Sub District, Indonesia were important factors for the successful observation and case studies with 13 mathematics teachers in the area. The researcher received permission and good response from them during the study conducted in year 2010 to 2012. In the localized study of ICT conditions, the author discussed the important of technology-based learning with them.

In general, the head of education office supports the observation activity and agrees that technology based learning is good to be implemented. A similar response was received from heads of schools. Hopefully concrete policies in regard to ICT for technology could be formulated and implemented due to their positive concern about the benefit of ICT for education.

The tools developed were designed to empower teachers to use ICT for teaching and learning using their own devices. It can help teachers optimizing resource

accessibility via the internet and documenting their learning designs. However it is not easy to change the habit and tradition of paper-based resources and learning designs of teachers and their institutions. In the authors view, it would be good to have the electronic mapping system integrated to education system for use by mathematics teachers. The researcher believes many improvements are needed for the tools to be ready for the real implementation. In addition, it will take time and need a good approach to the government for this. In Indonesia, the education system is tends to be centralised. Teachers, heads of schools, even the head of education office of Bojonegara Sub District would need approval and written instruction from the central government to implement change or to formally implement innovation in teaching and learning.

However, this study provides a way of empowering teachers. In the future, continuous development of electronic mapping system will be important.

In regard to the expansion of use of the electronic mapping system for hyperlearning, curriculum review and embedded mathematics learning support system at the university level, the institutional support from the head of school or department or Dean/Rector as policy makers in this level will be required. Results of the empirical study in hyperlearning can provide evidence for policy about the implementation of hyperlearning for replacement of conventional learning in some conditions, to provide variety of learning experiences with technology, without affecting students' academic achievement in their institutions. On the other hand, the capability of LDMap to document learning designs to facilitate curriculum review could be benefit for educators' institutions..

6.5 Dissemination

The institutionalisation phase of evaluation focuses on uptake and ongoing use by others or institutions, and in the context of the time to complete a thesis, this is difficult to demonstrate as more time needs to elapse for the tools to be embedded

through use. A closely allied concept encompassing institutionalisation is that of dissemination.

> *Dissemination is more than distribution of information or making it available in some way. While embracing this aspect, dissemination also requires that some action has been taken to embed and upscale the innovation within its own context (discipline or institution) and or to replicate or transform an innovation in a new context and to embed the innovation in the new context (Australian Learning & Teaching Council (ALTC), 2008)*

In the Alexander and Hedberg model (1994) institutionalisation focussed on the uptake component, but the question of how to invoke that uptake involves reflection on the earlier aspects of the ALTC statement. Dissemination of the electronic mapping systems is considered to be an important aspect of the innovation's future success. However the good the tools are in performing their function, if they are not known or used then in terms of the final phase of evaluation they will not be successful. While the worth of innovation has to some extent been evaluated using Alexander and Hedberg's model (see chapter 4, section 4.4), dissemination needs to continue beyond the initial implementations; the innovation needs to be sustained through use by others.

Dissemination can be considered to involve two forms, engagement and the corresponding information provision (ALTC, 2008, p. 1), and through these forms, to replicate or transform this innovation to a new context, such as used by lecturers and students for hyperlearning, curriculum review, and embedded learning support system (see chapter 5, section 5.2). The wide use and culture of use may drive the institutionalization and sustainability of the electronic mapping system in the future.

The six forms of engagement identified by the ALTC and how these have been addressed in this thesis are as follows:

1) Identify potential users and stakeholders.

   For this project the primary users and stakeholders are educators in developing countries with later inclusion of educators from developed nations. The

electronic mapping system, was developed and implemented in Bojonegara Sub District to enable mapping of resources on the internet and the documents and the sharing of mathematical teaching and learning. 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.

Other potential users and stakeholders of the electronic mapping system include mathematics teachers in developing countries in particular, mathematics educators in general, and their institutions. To enable the wide use of the technology-based tools, researchers have licensed the tools with a creative common license. This license allows mathematics teachers and lecturers all over the world to use, modify and share electronic mapping system on a non-commercial basis.

2) Describe strategies to engage with the users throughout the project development, focusing on the intended adoption.

To ensure the successful introduction of the innovation, needs based analyses were undertaken with samples of educators from the intended population at each phase of the original development. Improving usability relied on academics from a developed university, who could provide visions for future use, although extension of use remained consistent with the technology available in developing countries.

3) Identify the range of project outcome and potential users of the different outcomes that could be adopted and implemented by different groups.

To maximise engagement of potential users a variety applications of the tools were demonstrated expanding the pool of potential teachers and lecturers interested in the outcomes that could be adopted and implemented. The primary group are teachers and lecturers who may wish to engage in:

- mapping resources accessible via the internet, to facilitate easy access to resources, for use in hyperlearning, or teaching to distance students.

- documentation of mathematics learning designs in the form of Learning Design Maps (LDMap) which can subsequently facilitate curriculum review using LDMaps .
- development of embedded learning support systems to facilitate student access to internet resources provided or recommended by teachers for teaching and learning using GRMap.

Through a process of demonstration the tools were refined in terms of functionality, with use explored in several contexts, learning design maps, hyperlearning, curriculum review (subject outlines) and the provision of embedded online learning support systems. Strategies for enabling each identified group of intended users to become aware of the relevant outcomes and ideas and how they might be involved in making effective use of them have begun to be implemented. The learning design maps can be used by schools, universities, or other academic institutions to map the learning designs of their courses, providing a useful tool for curriculum design and re-design and curriculum mapping. 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 maps constructed by skilled practitioners using their previously identified learning resources and recorded designs for the conduct of learning. They can also modify the maps of others to construct their own version of learning design maps and share these.

4) Describe strategies for engaging with intended users and obtaining feedback during the project development.

The tools can be located on the web through search engines, and to obtain future feedback to guide modifications and to facilitate engagement with other users the contact details of the researcher are provided in the accompanying

documentation. The aim was to develop tools for teachers in developing countries, Indonesia being but one example of a developing country. The electronic mapping system is available in both Bahasa, the Indonesian language, the native language of country focus of this study, and English, the universal language used by many nations in the world.

Compilation of surveys results in regard to ICT for education in developing countries (Chapter 2, sections 2.1.2 to 2.1.4) revealed that the ICT situations in these countries in general are similar to ICT situation in Bojonegara Sub District, Indonesia. The implementation of the electronic mapping systems is also appropriate for these countries. For that reason, the electronic mapping system, could be used in developing countries for the advancement of technology-based teaching and learning mathematics. The availability of ICT-based tools for mapping resources and learning designs is likely to be of benefit for mathematics teachers in developing countries supporting them as they design and deliver mathematics teaching. The electronic maps are expected to be useful for schools and community, facilitating the circulation of resources and learning design amongst teachers and students.

5) Outline evaluation strategies on the impact of their project outcome with the intended user communities during and following the project development

As teachers use tools it is likely that their use and functionality will expand, and just as one participant in the study chose explore and then discuss these tools in a paper for publication in local journal it is possible that others will do similar things.

6) Describe strategies for enabling each identified group of intended users to become aware of the relevant outcomes and ideas and how they might be involved in making effective use of them.

Corresponding to each of these areas of engagement there is a need to inform stakeholders, educators, and to continue to have this information accessible beyond the term of this thesis. Five primary means of disseminating information

to people outside the study have been used; the provision of reports, seminars, conference papers, journal articles and an online presence with the storage of documentation and tools in a permanent, maintained University collection of resources (UOW Shareworld, accessible through Content Without Borders).

a) Reports

The first report entitled *The Real and Perceived of ICT Infrastructure, Facilities, and Resources for Implementation of Technology-based Learning: A Survey in Bojonegara Sub District, Banten Province, Indonesia* was produced in year 2011. The audience for this report was staff and students at University of Wollongong, Australia. This report briefly explain recent ICT conditions, in particular the availability of computer, internet and related devices at school and teachers' homes as well as the current practice and availability of resources and learning designs in Bojonegara Sub District, Indonesia.

In addition, three documents entitled 1) *How to Use, Modify, and Share Learning Design Tools, 2) How to Use, Modify, and Share Learning Designs-based Curriculum Reviewer,* and *3) How to Use, Modify, and Share Embedded Learning Support System* have been produced in 2013. Documentaion is available in the English and Bahasa languages. The documentation, guides users on how to implement and adapt the electronic mapping systems so they can respond to the needs of their educational environments.

b) Seminars to staff and students at the University of Wollongong

Four seminars (2011 - 2013) have been delivered to staff and students, including international students from developing countries, at the University of Wollongong. The first seminar was in order to upgrade from Master by Research Program to PhD program (year 2011), the second seminar also presented in the CSSM regular seminar series was the Annual Proposal

Review seminar (year 2012), the third seminar was preparation for the presentation of a paper for oral presentation at the 12th International Congress on Mathematical Education 2012 (ICME-12), Seoul South Korea 2012, and the fourth seminar presented in the NIASRA seminar series (year 2013) provided preparation for an oral presentation in the 23rd Society for Information and Technology and Teachers Education (SITE) in New Orleans, United States.

c) Conference presentations

Three conference presentations in three different continents, 1) Europe in 2011, 2) Asia in 2012, and 3) America in 2013 were conducted to disseminate and communicate results of research to the education community. Following is list of conference presentation:

[1] Fathurrohman, M., and Porter, A. (2011). Modifiable and Shareable Electronic Maps of Mathematical Learning Resources for Use in Developing Countries; A Case Study of Bojonegara Sub District, Indonesia. **The World Conference on Educational Multimedia, Hypermedia and Telecommunications, June 28 – July 1, 2011, Lisbon, Portugal.**

a. Available at: *http://www.editlib.org/p/38098/*
b. Full Paper in Section Case Study: Country Specific Developments.

[2] Fathurrohman, M., Porter, A., and Worthy, A., L. (2012). Maps of Learning Design for Teachers in Developing Countries to Document and Share Mathematical Teaching and Learning Experiences. **The 12th International Congress on Mathematical Education (ICME-12), July 8-15, 2012, Seoul, South Korea.**

a. Available at: *http://icme12.org/upload/UpFile2/TSG/0573.pdf*
b. Full Paper in Topic Study Group 18: Analysis of the use of technology in teaching mathematics.

[3] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Meta-development of Resources and Learning Designs: Providing ICT-based Tools for Use by Mathematics Teachers. **The 23rd International Conference of Society for Information Technology and Teachers Education (SITE). March 25-29, 2013, New Orleans, Louisiana, United States of America.**

a. Available at: http://www.editlib.org/p/48577
b. Full Paper in Section Information Technology Diffusion/Integration.

These presentations were aimed at raising audience awareness about the design and development of technology-based tools for use by mathematics teachers in developing countries.

d) Journal articles

Three journal articles have already been raised from this research project. The articles are published or accepted to published in peer reviewed journals ranked A or B journals by ERA (the Excellence in Research of Australia) year 2010. Following is list of journal articles.

[1] Fathurrohman, M., and Porter, A. (2012). Addressing the Needs of a Developing Nation: Electronic Maps of Mathematical Learning Resources Accessible Via the Internet. **Journal of Computers in Mathematics and Science Teaching (JCMST)**. Volume 31, No 4. Pp. 337-362.

   a. *http://www.editlib.org/p/38433/*
   b. The Excellence in Research of Australia (ERA) 2010 Ranked B Journal.

[2] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Learning Design Map (LDMap) for Mathematics Teachers in Developing Countries and the Benefit of Its Use for Curriculum Review. **The Electronic Journal of Mathematics and Technology (EJMT)**. Vol 8, No 1. Pp 88-101.

   a. https://php.radford.edu/~ejmt/deliverAbstract.php?paperID=eJMT_v8n2a2
   b. The Excellence in Research of Australia (ERA) 2010 Ranked B Journal.

[3] Fathurrohman, M., Porter, A., and Worthy, A., L. (2013). Comparison of Guided Hyperlearning, Unguided Hyperlearning and Conventional Learning in Mathematics: An Empirical Study. **The International Journal of Mathematical Education in Science and Technology (iJMEST)**. Online publication: 16 December 2013

   a. **http://dx.doi.org/10.1080/0020739X.2013.868541**
   b. The Excellence in **Research** of Australia (ERA) 2010 Ranked A Journal.

e) Online presence

Software developed during this research project has been made available for download and use through, the University of Wollongong, Shareworld Collection, housed in Equella. The ongoing maintenance and upgrade of this system is part of core university business, ensuring longevity of resources. The tools are made available to the world through the Australia collection

located at Content without Borders (available at: http://oer.equella.com, with titles 1) Embedded Mathematics Learning Support (refer Figure 6.1) and 2) Learning Design, Subject Outline and Curriculum Review Mapping Tools (refer Figure 6.2)). Two items are housed in the first collection, the resource mapping package, with the name Mapping tools for Mathematics along with the example MATH142 Learninglinks. The second item is comprised of the Learning Design mapping package (LDForm) and the associated Curriculum Review tools. The availability of the software, licensed as creative commons, in this website enables people from all over the world to access, use, modify, and share the electronic maps and the mapping systems for use in education, in particular for use by mathematics teachers and lecturers to document learning designs, conduct mathematics curriculum review, and to provide embedded learning support systems to take advantage of resources accessible via the internet.

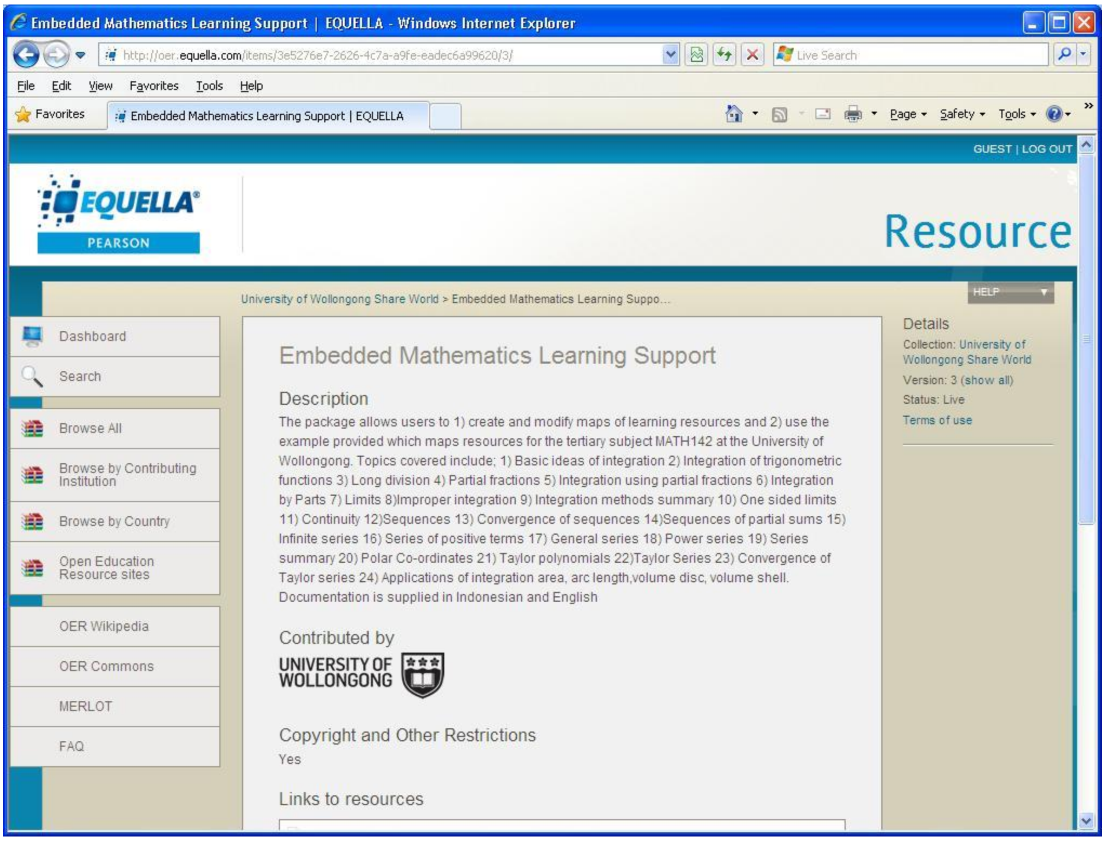


Figure 6.1 Shareworld item: Embedded Mathematics Learning Support

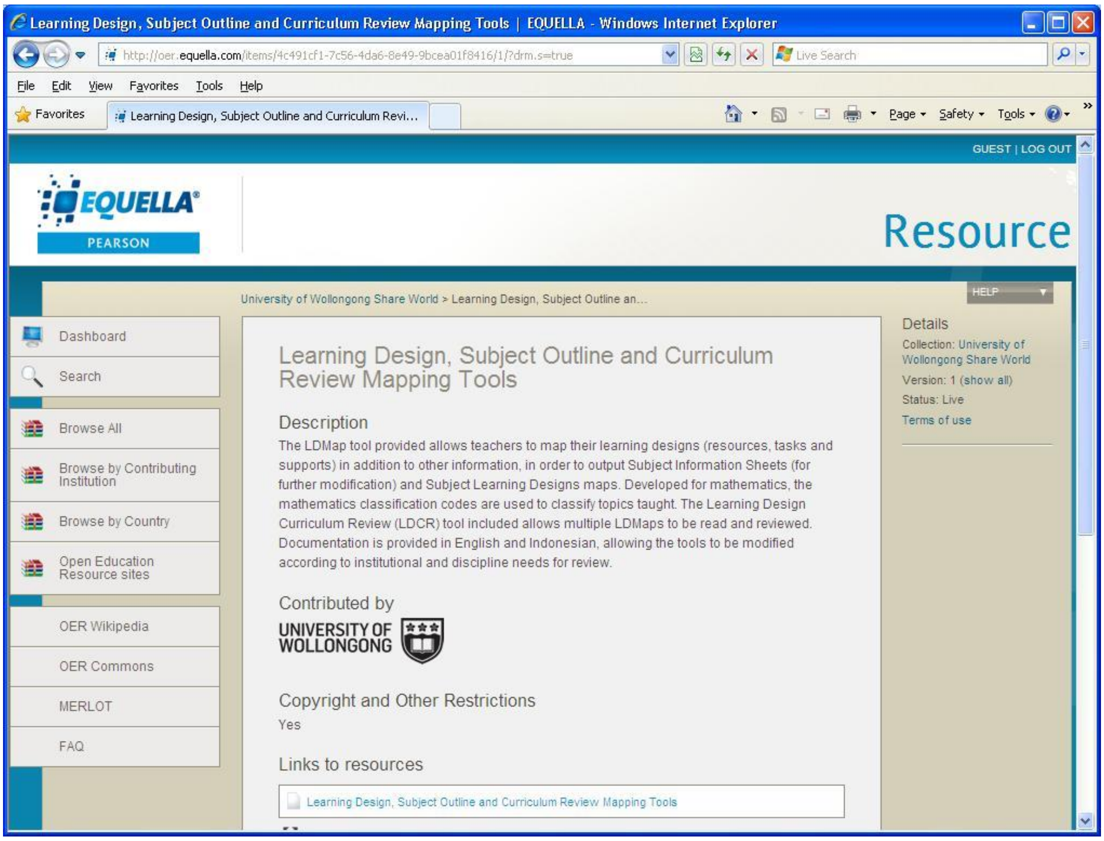


Figure 6.2 Shareworld item: Learning Design, Subject Outline and Curriculum Review Mapping Tools

6.6 Concluding remarks

An electronic mapping system for use by mathematics teachers in developing countries has been developed. The design and development of electronic mapping system was focused in Bojonegara Sub District, Indonesia, recognising that the tools developed were to a great extent context bound for use in developing countries. This reflects the fact that tool development typically involves studies that describe and analyze the design and development process, used in particular projects and are to a great extent context bound.The first part of the system, Geography-based Resource Map (GRMap) can be used to map mathematical learning resources accessible via the internet and this has been used to create an embedded learning support system MATH142 Learning Links, while the second part, Learning Design Map (LDMap), can be used to document and share learning designs. The creation and use of

electronic mapping system has been evaluated through implementation by teachers in developing countries, which suggested that the electronic mapping system has benefits for teachers, students, schools and community and as intended the technology is appropriate given current ICT in developing countries.

ICT conditions in Bojonegara Sub District, Indonesia, are in general similar to ICT condition in other regions in developing countries. It is likely that the implementation of an electronic mapping system is also appropriate to these countries. As teachers want to be able to share learning designs and resources in their teaching it is likely, the electronic mapping system can readily be used in developing countries and indeed developed countries for the advancement of technology-based teaching and learning in mathematics.

The wide range of uses integral to the functioning of schools and universities suggests that it has good prospects for adoption. The embedded support system created with GRmap is likely to be extended to other subjects, as embedded learning support has been found to impact of student learning and in particular to reduce failure rates (Aminifar, Porter, Caladine, and Nelson, 2007). Just as the GRMaps, can be used to create an embedded learning support system used in eLearning management systems, the resource maps can also be used in the classroom providing an alternative to conventional teaching and learning, namely guided hyperlearning through which students can achieve the same academic results as in conventional learning. Guided hyperlearning may be suitable in circumstances, where for example there is a distance problem between lecturer and students, or where the number of students is too high for effective conventional learning. In terms of curriculum review, which is less likely to be of importance at the school level than it is at the university level, interviews in Australia suggest that the curriculum mapping using LDMap, while suitable in low budget environments such as developing countries, may need additional development where budgets are higher and expectations are greater in terms of incorporating functions and processes that are integrated with centralised computing in universities in developed countries. By providing modifiable tools to produce and share LDMaps, which contains learning designs data that can be extracted and aggregated for automatic results in curriculum review, the

electronic mapping systems can be adapted for educators and units with different needs. All tools, associated documentation and examples of use are available and shareable under Creative Commons license through Content without Borders.

6.7 Recommendations

Maintainability and sustainability in part depend upon the ease with which one can modify the tools to meet future needs. Documentation is part of this. However another part is embedding the use, so that colleagues around a user can assist. To create this culture of use depends in part upon the widespread appeal that comes from the multiple purposes that the tools can be used for, sharing resources, sharing learning designs, curriculum review, embedded learning support and formalised production of curricula in the form of a map.

To create this culture has involved and needs to continue to involve dissemination of the results and ideas contained in this thesis, particularly the ideas of 1) Mapping resources accessible through the internet, and 2) Documenting and sharing learning designs through a variety of mechanisms as already discussed.

Building the culture of use of the electronic mapping system is possible through extending its use in teaching and learning of mathematics to other disciplines that also use classifications of subject matter, for example, Physics. The tools also need to evolve as technology evolves, with the tools being extended to other emerging and widely used operating systems and platforms, such as Mac, iOS, and android tablets. Based on responses from published papers thus far the spread and usability of the tools could be leveraged by providing this electronic mapping system not only for teachers and lecturers in developing countries, but also for a possible use by teachers and lecturers in developed countries.

REFERENCES

A

[1] Absolum, M. (1995). *A Guide to Curriculum Review*. Auckland: New Zealand

[2] Agostinho, S. (2009). Learning design representations to document, model, and share Teaching Practice. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Applications, and Technologies*. New York: Information Science Reference.

[3] Agostinho, S., Oliver, R., Harper, R., et al. (2002). A tool to evaluate the potential for an ICT-based learning design to foster "High-Quality Learning". *Proceeding of ASCILITE* 2002, pp. 29-38.

[4] Akca, H., Sayili, M., and Esengun, K. (2007). Challenge of rural people to reduce digital divide in the globalized world: theory and practice. *Government Information Quarterly*. 24, 404-413.

[5] Alexander, S., and Hedberg, J., G., (1994). Evaluation technology-based learning: Which model? In Beattie, K., McNaught, C., and Wills, S. (1994). *Interactive Multimedia in University Education: Designing for Change in Teaching and Learning*. Elsevier Science B. V.

[6] Allen, D. (1996). Teaching with technology. *Teaching Pre K-8*, 27(3), pp. 14-16.

[7] ALTC. (2008). *ALTC Dissemination Framework*. Australian Learning and Teaching Council.

[8] Aminifar, E., Porter, A., Caladine, R., and Nelson, M. (2007). Creating mathematical learning resources - combining audio and visual components. *ANZIAM Journal* 47 (EMAC2005).

[9] Azevedo. R., and Jacobson, M., J. (2007). Advances in scaffolding learning with hypertext and hypermedia: a summary and critical analysis. *Educational Technology Research and Development*, 56, pp. 93-100.

B

[10] Bada, J.K., Khazali, B. (2006). An empirical Study on Education Strategy to E-learning in a developing country. *Proceedings of the 4th IEEE International Workshop on Technology for Education in Developing Countries*.

[11] Baharun, N. (2012). Improving students' learning of statistics: the impact of web-based learning support on student outcomes. PhD Thesis University of Wollongong.

[12] Baker, D., Edwards, R., and Marsahall, C. (1990). Teaching about exponents with calculators. *The Arithmetic Teachers*, 38(1), pp. 38-40.

[13] Ball, D., L., and Even, R. The International Commission on Mathematical Instruction (ICMI) – *The Fifteen ICMI Study: The Professional Education and Development of Teachers of Mathematics*. ICMI.

[14] Barber, L., K., Bagsby, P., G., Grawitch, M., J., et al. (2011). Facilitating self-regulated learning with technology: evidence for student motivation and exam improvement. *Teaching of Psychology*, 38, pp. 303-308.

[15] Barbera, M. (2006). "The HyperLearning Project: Towards a Distributed and Semantically Structured e-Research and e-Learning Platform". *Literary and Linguistic Computing*. Vol 26, No 1.

[16] Batane, T. (2006). When computers are scarce: a case of Bostwana schools. *Proceedings of the 4th IEEE International Workshop on Technology for Education in Developing Countries*.

[17] Beaudrie, B., and Boschmans, B. (2004). Infusing technology into mathematics lessons. *Media and Methods*, 41(1), p. 10.

[18] Bendixen, L., D., and Hartley, K. (2003). Successful learning with hypermedia: The role of epistemological beliefs and metacognitive awareness. *Journal of Educational Computing Research*, 28(1), pp. 15-30.

[19] Beynon, M. (2006). Towards technology for learning in a developing world. *Proceedings of the 4th IEEE International Workshop on Technology for Education in Developing Countries.*

[20] Bhola, H. S. 1989.*World trends and issues in adult education*. London: Jessica Kingsley; UNESCO

[21] Binnur. (2009). Effect of technology on motivation in EFL classroom. *Turkish Online Journal of Distance Education*, 10(4), pp. 136-158.

[22] Bleakley, A., and Carrigan, J. L. (1994). *Resource-Based Learning Activities*. Iowa: American Library Association.

[23] Blignaut, A., S., Hinostroza, J., E., Els, C., J, and Brun, M. (2010). ICT in education policy and practice in developing countries: South Africa and Chile Compared through SITES 2006. *Computer & Education*, 55, pp. 1552-1563.

[24] Boyle, T. (2009). The design of learning objects for pedagogical impact. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Applications, and Technologies*. New York: Information Science Reference.

[25] BPS-Statistics Indonesia. (2012). *Statistical Yearbook of Indonesia 2012*. Jakarta: BPS-Statistics Indonesia.

[26] Bradford, P., Porciello, M., Balkon, N., et al. (2006). The Blackboard Learning System: the be all and end all in educational instruction?. *Journal of Educational Technology Systems*, 35(3), pp. 301-314.

[27] Brisson, Z., and Krontiris, K. (2012). *Tunisia: From Revolution to Institution*. Washington: InfoDev.

[28] Brownhill, S., Wilhelm, K., and Watson, A. (2006). "Losing Touch": Teachers on Teaching and Learning. *Asia-Pacific Journal of Teacher Education*, 34(1), pp. 5-26.

[29] Brundett, M. (2011). The national curriculum review: remit and response. *International Journal of Primary, Elementary, and Early Years Education*. Vol 39, No 3.

[30] Bukova-Guzel, E., and Canturk-Gunhan, B. (2010). Prospective mathematics teachers' view about using flash animations in mathematics lessons. *International Journal of Social Sciences*, 5(3), pp. 154-159.

[31] Burn, M. 2006. Using ICT for teacher professional development in Namibia. Working Paper No 1. InfoDev.

C

[32] Callaghan, L., Lea, S., J., Mutton, L., and Whittlesea, E. (2011). Enhancing health students’ understanding of generic research concepts using a web-based resource. *Nurse Education in Practice*, 11, pp. 375-379

[33] Calverley, G., and Shephard, K. (2003). Assisting the uptake on online-resources: Why Good Learning Resources are not enough. *Computers and Education*. Vol 41.

[34] Campbell, C., and Cameron, L. (2011). Introducing learning design and LAMS to pre-service teachers: when is the best time to do it?. In T. Bastiaens & M. Ebner (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011. Chesapeake, VA: AACE.

[35] Cennamo, K., S., Ross, J., D., and Ertmer, P., A. (2010). *Technology Integration for Meaningful Classroon Use*. Belmont: Wadsworth

[36] Chapman, O. (2012). Challenges in mathematics teachers education. *Journal of Mathematics Teachers Education*. Vol. 15

[37] Chinnappan, M. (2009). Reconceptualisation of learning objects as meta-schemas. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Applications, and Technologies*. New York: Information Science Reference.

[38] Churchill, D., and Hedberg, J., G. (2009). Learning objects, learning tasks, and handhelds. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Applications, and Technologies*. New York: Information Science Reference.

[39] Clarke, K. S., and Miller, D. R. (2003). *Putting XML to Work in the Library: Tool for Improving Access and Management*. Chicago: American Library Association.

[40] Commission for Developing Countries. (2012). Individual support program. Available at http://www.mathunion.org/cdc/grants/individual-support-program/. Accessed in 9 January 2013.

[41] Coronel, C., Morris, S., and Rob, P. (2013). *Database Systems: Design, Implementation, and Management* (10e). Boston: Course Technology Cengage Learning.

[42] Cramer, D., and Howitt, D. (2004). *The Sage Dictionary of Statistics*. London: SAGE

[43] Creswell, J., W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Method Approach.* London: SAGE Publications

[44] Czaja, S., J., and Sharit, J. (2013). *Designing Training and Instructional Programs for Older Adults*. Boca Raton: CRC Press.

D

[45] Delgaty, L. (2009). Curriculum mapping: are you thinking what I'm thinking? A visual comparison of standardized, prescriptive programmes. *ARECLS*, Vol 6, pp. 35-38.

[46] DeLuca, V., W., and Lari, N. (2013). Developing students' metacognitive skills in a data rich environment. *Journal of STEM Education*, 14(1), pp. 45-55.

[47] DeVaus, D., A. (2002). *Surveys in Social Research* (5th Edition). Crows Nest: Allen & Unwin.

[48] Davis, E. (1981). *Teachers as Curriculum Evaluators*. Sydney: George Allen & Unwin Australia Pty Ltd

[49] Dickenson, J., P., Clarke, C., G., Gould, W. T. S., et al. (1983). *Geography of the Third World*. London: Methuen

[50] Dressel, P., L. (1965). The need for curriculum review: courses, qualities, and costs. *The Journal of Higher Education*. Vol 36, No 8.

[51] Drier, H., S. (2001). Teaching and learning mathematics with interactive spreadsheets. *School Science and Mathematics*, 101(4), .pp. 170-179.

[52] Dominick, G., M., Friedman, D., B., and Hoffman-Goetz, L. (2009). Do we need to understand the technology to get to the science? A systematic review of the concept of computer literacy in preventive health programs. *Health Education Journal*, 68, pp. 296-313.

[53] Duncan, D., Lockhart, L., and Ham, L. (2012). *The New iSearch, You Search, We All Learn to Research*. New York: Neal-Schuman Publishers, Inc.

[54] Dzvimbo, K., P. (2013). Negotiating global and local spaces: challenges and possibilities of integrating ICTs in initial teacher education discourse practices in Sub-Saharan Africa. The 24th SITE 2013 conference, New Orleans, Louisiana, United States.

E

[55] Editorial. 1999. Editorial: access to resources. *Journal of Computer Assisted Learning*. Vol 15, No 1.

[56] Eggen, P., & Kauchak, D. (2004). *Educational Psychology; Windows on Classroom*. New Jersey: Pearson

[57] Eggleston, J. (2004). *Teaching and Learning Design and Technology: A Guide to Recent Research and Its Application*. London: Continuum.

[58] English, Lyn D. (2008). *Handbook of International Research in Mathematics Education* (2nd Edition). New York: Taylor and Francis.

[59] Eng Tek Ong and Ruthven, K. (2010). The distinctiveness and effectiveness of science teaching in the Malaysian "Smart School". *Research in Science and Technological Education*, 28(1), pp. 25-41.

F

[60] Farrel, G., Isaacs, S., and Trucano, M. (2007). *Survey of ICT and Education in Africa* (Volume 2). Washington, DC: InfoDev/ World Bank.

[61] Ferrer, R., C., and Ferrer, G., J. (2012). Development and validation of proficiency test for undergraduate students. *Academy of Educational Leadership Journal*, 16, pp. 1-24.

[62] Finger, G., Russell, G., Jamieson-Proctor, R., and Russell, N. (2007). *Transforming Learning with ICT: Making It Happen*. Frenchs Forest: Pearson Education Australia.

[63] Flier, R., and Fowler, H. (2007). Educational uses of blogs and wikis. *The Phi Delta Kappa*, 89(3). Pp. 1-2

[64] Forster, P. A. (2006). Assessing technology-based approach for teaching and learning mathematics. *International Journal of Mathematical Education in Science and Technology*. Vol 37, No 2.

[65] Fry, H., Pearce, R., and Bright, H. (2007). Re-working resource-based learning - a case study from masters programme. *Innovations in Education and Teaching International*, 44(1), pp. 79-91.

G

[66] Gagne, R. M., Briggs, L. J., Wager W. W. 1988. *Principles of Instructional Design*. Forth Worth: Holt, Rinehart, and Winston, Inc.

[67] Geer, R., and Sweeney, T. (2008). Students' voices about learning with technology. *Journal of Social Sciences*, 8(2), pp. 294-303.

[68] Goldfarb, C. F. (2004). *XML Handbook* (5th Edition). New Jersey: Pearson Education

[69] Gog, T., Paas, F., Savenye, W., et al. (2008). Data collection and analysis. In Spector, J., M., Merrill, M., D., Merrienboer, J., V., and Driscoll, M., P. (2008). *Handbook of Research on Educational Communications and Technology*. New York: Routledge.

[70] GOK, T. (2012). Real-time assessment of problem solving of physics students using computer-based technology. *H. U. Journal of Education*, 43, pp. 210-221.

[71] Gomm, R. (2008). *Social Research Methodology: a Critical Introduction* (2nd Edition). Hampshire: Palgrave Macmillan

[72] Gonzales, M., Adiego, J., Sanz, L., Garcia, and R., Hermo, C. (2006). Can the WWW help to reduce the digital divide? an example of cost effectiveness in teaching laboratory development. *Proceedings of the 4th IEEE International Workshop on Technology for Education in Developing Countries*.

[73] Gonzales, J., and Sherer, T. E. (2004). *Geography (2nd Edition)*. Indianapolis: Penguin Group

[74] Goulden, B. (2005). Building ICT regulatory capacity in developing economies: a learning framework for regulators. *Inform*. Vol 4, No 7.

[75] Gregory,S., Gregory, B., Campbell, M., et al. (2010). Australian higher education institutions transforming the future of teaching and learning through 3D virtual worlds. Sydney: *ASCILITE* 2010

[76] Guion, L., A., Diehl, D., C., and McDonald, D. (2002). Triangulation: establishing the validity of qualitative studies. University of Florida.

H

[77] Hall, A. (2009). Designing online learning environments for local contexts, as exampled in the Sultanate of Oman. PhD Thesis at University of Wollongong. Unpublished.

[78] Harden, R., M. (2001). AMEE guide no 21: curriculum mapping: a tool for transparent and authentic teaching and learning. *Medical Teacher,* 23(2), pp. 123-137.

[79] Harper, B., and Oliver, R. (2009). Developing taxonomy for learning designs. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Application, and Technologies. New York: Information Science Reference*.

[80] Haycock, K. (2006). Information literacy programs can foster discipline inquiry. *Teacher Librarian*, 33(3), p. 38

[81] Hesse-Birer, S., N. (2010). *Mixed Methods Research: Merging Theory with Practice*. Taylor and Francis.

[82] Hollebrands, K., F. (2007). The role of dynamic software program for geometry in the strategies high school mathematics students employ. *Journal for Research in Mathematics Education*, 38(2), pp. 164-192.

[83] Hudson, R. (2012). Modelling Secondary Mathematics Teachers' Use and Non Use of Technology in Teaching. PhD thesis, University of Wollongong.

I

[84] IMF. (2010). World Economic Outlook April 2010. Available at: http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/groups.htm#oem

[85] Ingvarson, L., Beavis, A., Bishop, A., Peck, R., and Elswoth, G. (2004). *Investigation of Effective Mathematics Teaching and Learning in Australian Secondary Schools.* Australian Council for Educational Research.

[86] International Commission on Mathematical Instruction. (2001). Mathematics Education in different cultural tradition: a comparative study of East Asia and the West. *ZDM International Journal of Mathematics Education*. Vol 33, No 4.

J

[87] Jacobson, M., J., and Kozma, R., B. (2000). *Innovations in Science and Mathematics Education: Advanced Designs for Technologies of Learning. London.* Lawrence Erlbaum Associates, Publishers.

[88] Jacobson, M., J., and Azevedo, R. (2007). Advances in scaffolding learning with hypertext and hypermedia: theoretical, empirical, and design issues. *Educational Technology Research and Development*, 56, pp. 1-3.

[89] Jalote, P. (2005). *An Integrated Approach to Software Engineering*. New York: Springer

[90] Johnson, R., Kemp, R., Kemp, E., Blakey, P. (2006). The learning computer: a low bandwidth tool for bridging the digital divide in distance education. *Proceedings of the 4th IEEE International Workshop on Technology for Education in Developing Countries.*

[91] Jones, C. (2007). Using a digital repository for managing digital rights and copyright information. Singapore: *ASCILITE* 2007

K

[92] Kallick, B., and Colosimo, J. (2009). *Using Curriculum Mapping and Assessment Data to Improve Learning*. California: Corwin Press.

[93] Kay, R. (2011). Exploring the impact of web-based learning tools in middle school mathematics and science classroom. *Journal of Computers in Mathematics and Science Teachings*. Vol 30 No 2.

[94] Kervin, L., Vialle, W., Herrington, J., and Okely, T. (2006). *Research for Educator*. Victoria: Cengage Learning.

[95] Khadivi, M., R. (2006). Computers and mathematical philosophies in educational trends. *Journal of Computers in Mathematics and Science Teaching*, 25(3), pp. 239-250.

[96] Khalifa, M., and Kwok, R., C. (1999). Remote learning technologies: effectiveness hypertext and GSS. *Decision Support Systems*, 26, pp. 195-207.

[97] Khan, A. W. (2000). On-Line distance learning: a model for developing countries. *Journal of Studies in International Education*. Vol 4, No 11.

[98] Kissane, B. (2011). Learning mathematics and the internet. Available at: www.staff.murdoch.edu.au/~kissane/pd/Internetmaths.htm. Retrieved: 22 May 2011.

[99] Kleinpell, R., Williams, G., and Liolios, A. (2011). Web-based resources for critical care education. *Critical Care Education, 39(3), pp. 541-543.*

[100] Koper, R., and Tattersall, C (2005). *Learning Design: a handbook on Modelling and Delivering Networked Education and Training*. Berlin: Springer.

[101] Koppang, A. (2004). Curriculum mapping: building collaboration and communication. *Intervention in School and Clinic*, 39(3), pp. 154-161

L

[102] Lai, J., Wood, L., and Marrone, M. (2012). Implementation of curriculum management tool: challenges faced by large Australian university. *Asian Social Science*, 8(14), pp. 28-36.

[103] Langrall, Mooney, Nisbet, & Jones. (2008). Elementary students' access to powerful ideas of mathematics in English, Lyn D. (2008). *Handbook of International Research in Mathematics Education* (2nd Edition). New York: Taylor and Francis.

[104] Loch, B., Gill, O., and Croft, A., C. (2012). Complementing mathematics support with online Mathcast. *ANZIAM Journal*, 53, pp. C561-C575.

[105] Lockyer, L., Bennett, S., Agostinho, S., & Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Application, and Technologies*. Volume 1. New York: Information Science Reference.

[106] Löffelmann, K., and Purohit, S. K. (2011). *Microsoft Visual Basic 2010 Developer's Handbook*. California: Microsoft Press.

[107] Lyytine, K., Rose, G., & Yoo, Y. (2010). Learning routines and disruptive technological change: hyper-learning in seven software development organizations during internet adoptions. *Information Technology and People*, Vol 32. Issue: 2

M

[108] MacDonald, L., Vasques, S., and Caverly, D., C. (2002). Techtalk: effective technology use in developmental mathematics. *Journal of Developmental Education*, 26(2), pp. 36-37.

[109] Macdonald, J., Mason, R., and Heap, N. (2006). Refining assessment for resource-based learning. *Assessment and Evaluation in Higher Education*, 24(3), 345-353.

[110] MacDonald, M. (2013). *Access 2013: the Missing Manual*. Sebastopol: O'Reilly Media.

[111] Mamona-downs & Downs. (2008). Advanced mathematical thinking and the role of mathematical structure in English, Lyn D. (2008). *Handbook of International Research in Mathematics Education* (2nd Edition). New York: Taylor and Francis.

[112] Marcum, J., W. (2002). Rethinking information literacy. *The Library Quarterly*, 72(1), pp. 1-26.

[113] Marshall, S, and Taylor, W. (2009). Editorial: potential and challenges in the use and adoption of ICT. International Journal of Education and Development using Information and Communication Technology, 5(3).

[114] Marshall, S., Taylor, W., and Yu, X. (2003). *Closing the Digital Divide: Transforming Regional Economies and Communities with Information Technology*. London: Praeger.

[115] Mason, J. (2007). "Hyper-learning from hyper-teaching: what might the Future hold for learning mathematics from & with e-screen". *Interactive Educational Multimedia*, No 14.

[116] Masterman, E. (2009). Activity theory and the design of pedagogic planning tools. In Lockyer, L., Bennett, S., Agostinho, S., and Harper, B. (2009). *Handbook of Research on Learning Design and Learning Objects; Issues, Application, and Technologies*. New York: Information Science Reference.

[117] Masterman, E., Jameson, J., and Walker, S. (2009). Capturing Teacher' Experience of Learning Design Through Case Studies. *Distance Education*. Vol 30, No 2.

[118] Mathematics Subject Classification (MSC) 2010. Available at: http://www.ams.org/mathscinet/msc/msc2010.html. Accessed: 21 August 2012.

[119] Mbarika, V., W. (2004). Approaching Sub-Saharan Africa's educational dilemma with tele-education. *IEEE Technology and Society Magazine*, Winter 2003/2004, pp. 20-25.

[120] McCarthy, D., S. (2008). Communications in mathematics: preparing pre-service teachers to include writing in mathematics teaching and learning. *School Science and Mathematics*, 108(7), pp. 334-340.

[121] McGuire, K. (2011). Keeping texters on their toes. *Tech-Learn Connection,* February 2011.
[122] McQuenn, T., F., and Fleck, R., A. (2004). The future of online learning: A look at WebCT's Vista. Allied *Academies International Conference,* 9(2), pp. 43-47
[123] Mertens, M. D. (2010). *Research and Evaluation in Education and Psychology*. California: SAGE Publication.
[124] Millard, D., L. (1998). Grab students' attention with multimedia. *ASEE Prism*, 8(4), pp. 26-29.
[125] Miller, D. R., and Clarke, K. S. (2004). *Putting XML to Work in the Library: Tools for Improving Access and Management*. Chicago: American Library Association
[126] Ministry of Education and Culture. (2012). *Dokumen Kurikulum 2013*. Jakarta: Ministry of Education and Culture.
[127] Ministry of National Education. (1999). Integrated resource package 1995. Canada. Available at: www.bced.gov.bc.ca/irp/welcome.php. Accessed: October 2010
[128] Moen, A., Nygard, K., A., and Gauperaa, T. (2009). Web-based learning resources – new opportunities for competency development. *Studies in Health Technology and Informatics*, pp 529-533.
[129] Moen, A., Smordal, O., and Sem, I. (2009). Web-based resources for peer support – opportunities and challenges. *Studies in Health Technology and Informatics,* pp. 302-306.
[130] Moore, J. W. (2008). Mathematics education. *Chemical Education Today*. Vol 85. Pp 1019
[131] Morris, M., M. (2008). Evaluating university teaching and learning in an outcome-based model: Replanting Bloom. PhD Thesis, University of Wollongong.
[132] Morrison, G., R., Ross., S., M., O'Dell, J., K. (1991). Application of research to the design of computer-based instruction. In Anglin, G., J. (1991). *Instructional Technology: Past, Present, and Future*. Eglewood: Libraries Unlimited, Inc.
[133] Mosquera, F., M. (2001). CALT: exploiting internet resources and multimedia for TEFL in developing countries. *Computer Assisted Language Learning*. Vol 14, No 5.
[134] Mtetwa, D., K., J. (2005). Some characteristics of mathematics teaching in Zimbabwean infant and primary school classrooms. *International Journal of Early Years Education*. Vol 13, No 3.
[135] Murray, J. (2003). Discovering democracy through resource-based learning. *ACCESS*, p. 20-22
[136] Musa, P., F., Meso, P., Mbarika, V., W. (2005). Toward sustainable adoption of technologies for human development in Sub-Saharan Africa: Precursors, Diagnostics, and Prescriptions. *Communications of the Association for Information Systems*. 15, pp. 592-608.

N

[137] Nason, R., Chalmers, C., and Yeh, A. (2012). Facilitating growth in prospective teachers' knowledge: teaching geometry in primary schools. *Journal of Mathematics Teacher Education*, 15, 227-249.

[138] Ndahi, H., B., Charturvedi, S., Akan, A., O., and Pickering, J., W. (2007). Engineering education: web-based interactive learning resources. *The Technology Teacher*, 67(3), pp. 9-14.

[139] Novak, J., D. (1990). Concept mapping: A useful tool for science education. *Journal of Research in Science Teaching*, 27(10), pp. 937-949.

O

[140] O'Connor, D., P. (2013). Repeated measures: measurement in health and exercise science. Available at at: http://grants.hhp.uh.edu/doconnor/PEP6305/Topic%20010%20Repeated%20Measures.htm. Accessed: 21 August 2013

[141] OECD. (2000). *Schooling for Tomorrow, Learning to Bridge the Digital Divide*. Paris: OECD.

[142] Olayi A., G. (1990). Mathematics curriculum in third world universities for prospective mathematics teachers. *International Journal of Mathematical Education in Science and Technology*. 21 (5), pp. 695-700.

[143] Oldknow, A., and Taylor, R. (2000). *Teaching Mathematics with ICT*. London: Continuum.

[144] Oliver, B., Fern, S., Whelan, B., and Lilly, L. (2010). Mapping the curriculum for quality enhancement: refining a tool and processes for the purpose of curriculum renewal. AuQF 2010 Quality in Uncertain Times, pp 80-88.

[145] Oxford Dictionaries. (2010). Available online at: http://oxforddictionaries.com/

P

[146] Pallant, J. (2010). *SPSS Survival Manual (4th Edition)*. New York : The McGraw-Hill Companies.

[147] Parizo, D., C. (2013). K-12 teachers' prepadness for utilizing technology to reduce classroom administrative workload. PhD Dissertation, Walden University.

[148] Peng, C., J., Long, H., and Abaci, S. (2012). Power analysis software for educational researchers. *The Journal of Experimental Education*, 80(2), pp. 113-136.

[149] Perelman, L. (1992). *School's Out: Hyperlearning, the New Technology, And the End of Education.* New York: Avon Books

[150] Perlin, M., S. (2011). Curriculum mapping for program evaluation and CAHME accreditation. *The Journal of Health Administration Education*. Winter 2011, pp. 27-47.

[151] Peterson, S., L., and Palmer, L., B. (2011). Technology confidence, competence, and problem solving strategies: Differences within online and face to face formats. *The Journal of Distance Education*, 25(2), pp. 1-16.
[152] Pierce, R., and Ball, L. (2009). Perceptions that may affect teachers' intention to use technology in secondary mathematics classes. *Educational Studies in Mathematics*, 71, pp. 299-317.
[153] Pierson, M., E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing Education*, 33, p. 413-430.
[154] Ponte, J. P. (2012). Mathematics teachers education program: practice and research. *Journal of Mathematics Teachers Education*. Online: 21 September 2012
[155] Porter, A., and Denny, S. (2013). *Building Leadership Capacity for Development and Sharing of Mathematics Learning Resources Across Disciplines and Universities.* Final Report. Office for Learning and Teaching.
[156] Posner, G. J. (2004). *Analysing the Curriculum*. New York: McGraw-Hill
[157] Psaromiligkos, Y., Spyridakos, A., and Retalis, A. (2012). *Evaluation in E-Learning*. New York: Nova Science Publisher, Inc.
[158] Purbo, O. (2010). Appropriate ICT for asia pacific. Digital Review of Asia Pacific. Available at: http://www.digital-review.org/themes/27-appropriate-ict-for-the-asia-pacific.html

R

[159] Reader, W., and Hammond, N. (1994). Computer-based tools to support learning from hypertext: Concept mapping tools and beyond. *Computers and Education*, 22(1-2), pp. 99-106.
[160] Reis, Z., A. (2010). Computer supported mathematics with GeoGebra. *Procedia*, 9, pp. 1449-1455.
[161] Reis, Z., A., and Ozdemir, S. (2010). Using GeoGebra as an information technology tool: parabola teaching. *Procedia*, 9, pp. 565-572
[162] Reusche. (2008). A blueprint for student success: aligning curriculum, instruction, professional development, and assessment. April 2008.
[163] Riddell, D. 2011. E-learning: HCP resources. *Community Practitioner*, Vol 84, No 4. Page 12.
[164] Roanes-Lozano, and Roanes-Macias, E. (2003). A bridge between dynamic geometry and computer algebra. *Mathematical and Computer Modelling*, 37, pp. 1005-1028.
[165] Rojano, T. (2008). Mathematics Learning in the middle school/ junior high School: student access to powerful ideas of mathematics in English, Lyn D. (2008). *Handbook of International Research in Mathematics Education* (2nd Edition). New York: Taylor and Francis.
[166] Ross, S., W., Morrison, G., R., Hannafin, R., D., Young, M., Akker, J., Kuiper, W., Richey, R., C., and Klein, J., D. (2008). Research Designs. In Spector, J., M., Merrill, M., D., Merrienboer, J., V., and Driscoll, M., P. (2008). *Handbook*

of Research on Educational Communications and Technology. New York: Routledge.

[167] Ross, T. W., & Bailey, G. D. (1995). *Technology-Based Learning; A Handbook for Principals and Technology Leaders*. New York: Scholastic Inc.

[168] Ruthven, K., Hennesy, S., and Deaney, R. (2005). Incorporating internet resources into classroom practice: pedagogical perspectives and strategies of secondary school subject teachers. *Computer & Education*, 44, 1-34.

[169] Ruthven, K., Laborde, C., Leach, J., and Tiberghien, A. (2009). Design tools in didactical research: instrumenting the epistemological and cognitive aspects of the design of teaching sequences. *Educational Researchers*, 38, pp. 329-342

[170] Ryan, M., Wells, J., Freeman, A., and Hallam, G. (1996). Resource-based learning strategies: implication for students and institutions. *Learning Technology*, 4(1), pp. 93-98.

S

[171] Saka, A. (2012). A different approach to have science and technology student-teachers gain varied methods in laboratory applications: a sample of computer assisted for application. *The Turkish Online Journal of Educational Technology*, 11(4), pp. 25-45.

[172] Sambell, K., McDowell, L., Montgomery, C. (2013). *Assessment for Learning in Higher Education*. New York: Routledge

[173] Sanga, C., E. T. Lwoga, and I. M. Venter. (2006). Open courseware as a tool for teaching and learning in Africa. *Proceeding of 4th IEEE International Workshop on Technology for Education in Developing Countries.*

[174] Sauers, M., P. (2001). *Using the nternet as Reference Tool: A How-to-Do-It Manual for Librarians and The Library Internet Trainers' Toolkit*. New York: Neal-Schuman.

[175] Schwab. (2012). *The Global Competitiveness Report 2012-2013*. Geneva: the World Economic Forum.

[176] Sekretariat Negara. (2013). *Daftar Gaji PNS.* Jakarta: Sekretariat Negara

[177] Setzer, V. (1989). *Computers in Education*. Edinburgh: Floris Books.

[178] Shanklin, N. (2008). Webquest: A literacy/technology practice that fosters adolescents' curiosity. *Voices from the Middle*, 16(1), pp. 48-49.

[179] Sherman, C., and Price, G. (2002). *The Invisible Web*. New Jersey: CyberAge Books.

[180] Smith, S. S. (2006). *Web-Based Instruction; A Guide for Libraries* (2nd Edition). Chicago: American Library Association.

[181] Silberschatz, A., Galvin, P., B., and Gagne, G. (2005). *Operating System Concepts*. New York: John Wiley and Sons.

T

[182] Tam, G., K., L., Lau, R., W., H., Zhao, J. (2009). A 3-D geometry model search engine to support learning. *International Journal of Distance Education Technologies*, 7(2), pp. 100-112.

[183] Tashakkori, A., and Creswell, J., W. (2007). Editorial: exploring the nature of research questions in mixed methods research. *Journal of Mixed Methods Research*, 1(3), pp. 207-211.

[184] Tella, A. (2012). System-related factors that predict students' satisfaction with the Blackboard Learning System at the University of Botswana. African *Journal of Library Archive and Information Science*, 22(1), pp. 41-52.

[185] Tergan, S., Graber, W., and Neumann, A. (2006). Mapping and managing knowledge and information in resource-based learning. *Innovations in Education and Teaching International*, 43(4), pp. 327-336.

[186] Thomas, J. (2007). New free software will help close digital divide in education: teachers worldwide will be able to share educational materials, form community. State Department Document, Jan 16, 2007.

[187] Thomas, M., K. (1999). Resource-based learning. *Knowledge Quest*, 27(4), pp. 26-30.

[188] Tittel, E., Pitts, N., and Boumphrey, F. (2002). *XML for Dummies*. New York: Hungry Minds

[189] Turban, E., King, D., McKay, J., Marshall, P., et al. (2008). *Electronic Commerce 2008*: A Managerial Perspective. New York: Prentice Hall.

U

[190] UNESCO. (2005). *Information and Communication Technologies in School: A Handbook for Teachers. Paris*: UNESCO.

[191] University Education Committee. (2012). *Meeting Agenda (14 November 2012)*. University of Wollongong

[192] Unz. D. C. & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, Vol 20, 3.

V

[193] Vahidi, B., and Khorsandi, A. (2010). Simulation of effect of voltage Sag on inrush current using MATLAB-SIMULINK for educational purpose. *Computers and Applied Engineering Education*, 20, pp. 629-623.

W

[194] Walliman, N. (2010). *Research Methods: The Basics*. Taylor and Francis.

[195] Wang, T. (2007). Web-based quiz-game-like formative assessment. *Computers and Education*, 51, pp. 1247-1263.

[196] Waschke, M. (2012). *Cloud Standards*. New York: CA Press.

[197] Wayman, J., C., and Stringfield, S. (2006). Technology-supported involvement of entire faculties in examination of student data for instructional improvement. *American Journal of Education*, 112(4), pp. 549-571.

[198] Wikipedia. (2013).Timeline of Operating System. Available at: http://en.wikipedia.org/wiki/Timeline_of_operating_systems. Accessed: 12 March 2013

[199] Williams, C. (2012). Curriculum mapping improves learning: Homegrown software enable teachers to update the curriculum regularly. *District Administration*. June 2012

[200] World Data (2010). *Encyclopædia Britannica*

Y

[201] Yao, Y., Trappey, A., J., C., and Ho, P. (2003). XML-based ISO9000 Electronic Document Management System. *Robotic and Computer Integrated Manufacturing* . Vol 19. Pp 355-357.

Z

[202] Zulnaidi, H., and Zakaria, E. (2012). The effect of using GeoGebra on conceptual and procedural knowledge of high school mathematics students.*Asian Social Science*, 8(11), pp. 102-106.

APPENDIX I. BOJONEGARA EDUCATION OFFICE LETTER OF APPROVAL

PEMERINTAH KABUPATEN SERANG
DINAS PENDIDIKAN
UPTD PENDIDIKAN KECAMATAN BOJONEGARA
Jl. Raya Bojonegara Telp. (0254) 5750309

SURAT KETERANGAN
No :..97./.071..-..Disp...

Yang bertandatangan dibawah ini,Kepala UPTD Pendidikan,Kecamatan Bojonegara,Kabupaten Serang.Dengan ini memberikan izin kepada :

Nama	**: MAMAN FATHURROHMAN**
No.ID	**: 3620657**
Institusi	**: University of Wollongong (UOW),Australia**

Untuk melakukan observasi dalam rangka kegiatan penelitian untuk Tesis studi lanjutnya yang berjudul : *Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries* pada tanggal 13 September 2010 sampai dengan 19 November 2010 di wilayah UPTD Pendidikan,Kecamatan Bojonegara,Kabupaten Serang,Provinsi Banten,Indonesia.

Demikian surat keterangan ini untuk dipergunakan dengan sebaik-baiknya.

Serang,19 Agustus 2010

Kepala UPTD Pendidikan
Kec.Bojonegara

PEMERINTAH KABUPATEN SERANG KECAMATAN UPTD PENDIDIKAN BOJONEGARA DINAS PENDIDIKAN

H.JUFRI,S.Ag,M.Si
NIP.195903071982061004

APPENDIX II. TRANSLATION OF PARTICIPANT INFORMATION SHEET USED IN OBSERVATION

HREC Approval Number: HE10/310

University of Wollongong

PARTICIPATION INFORMATION SHEET

Maman Fathurrohman
School of Math and Applied Statistics
Phone: (+61) 45 1818106
Email: mf704@uow.edu.au

Associate Professor Anne Porter
School of Math and Applied Statistics
Phone: (+61) 24 221 4058
Email: alp@uow.edu.au

Dear Teachers,

This is an invitation for you to participate in a study conducted by researchers at the University of Wollongong. The research is called ***Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries***. The purpose of this observation is to gain information from teachers about the current condition of ICT facilities & Infrastructure and technology-supported mathematical learning experiences in their schools. This information will be useful to get comprehensive understanding about implementation of technology-supported mathematical learning experiences, in particular Mathematical Learning Resources and Learning Designs, in developing countries.

Teachers are asked to fill in a confidential questionnaire that will take approximately 20 minutes to complete. Subject to your further agreement a small number of teachers are asked to participate in an interview about their conditions in their workplace, teaching experiences and use of and need for resources and learning designs. The interview is expected to take approximately 30 minutes, and it will be recorded and potentially published. Furthermore, subject to head of your school agreement, researcher also will record and taking photos of ICT facilities and infrastructure in your school.

Participation is not compulsory. You are free to decide if you want to be involved in this project or not. You any withdraw your permission to participate at any time. The final published results of the research will be aggregated measures and there will be no features that could lead to the identification of individual teachers.

Participation in this research is valuable as you can help the improvement of the mathematics learning experience through technology-supported learning resources and learning designs adapted for schools in developing countries.

If you have any concerns or complaints as to how the research is conducted you should contact the Secretary of the University of Wollongong Human Research Ethics Committee on (+61) (02) 4221 4457.

Thank you in anticipation of your willingness to participate.

APPENDIX III. TRANSLATION OF CONSENT FORM USED IN OBSERVATION

HREC Approval Number: HE10/310

University of Wollongong

School of Mathematics and Applied Statistics

Consent Form

Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries

Researchers:
Assoc Professor Anne Porter and Maman Fathurrohman

Please return the following statements to indicate your agreement to participate:

YES / NO • I agree to give permission to use my comments for this research

YES / NO • I agree to be contacted for further questions if they arise.

YES / NO • I agree to give permission to analyse my results in relation to the Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries.

YES / NO • I agree to give permission that video, photos or artefacts (copies of resources) can be used at conference/ seminar presentation

By signing below I am indicating my consent to participate in the research. I understand that my results will not identify me personally in any subsequent publication.

Signed　　　　　　　　　　　　　　　　　　Date

……………………………………… 　　　　……./……./ ....

Name

……………………………………

APPENDIX IV. TRANSLATION OF QUESTIONNAIRE FORM USED IN OBSERVATION

HREC Approval Number: HE10/310

University of Wollongong

English Translation

QUESTIONNAIRE

Contact:
Maman Fathurrohman
School of Math and Applied Statistics
Phone: (+61) 45 1818106
Email: mf704@uow.edu.au

Associate Professor Anne Porter
School of Math and Applied Statistics
Phone: (+61) 24 221 4058
Email: alp@uow.edu.au

Research Title:
Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries

Explanation:

1. The purpose of this questionnaire is to gain information from teachers about the current condition of ICT facilities & Infrastructure and technology-supported mathematical learning experiences in their schools.
2. This information will be useful to get comprehensive understanding about implementation of technology-supported mathematical learning experiences, in particular Mathematical Learning Resources and Learning Designs, in developing countries.
3. Techniques for answering questions:
    a. Choose A, B, C, D, or E by signed (with cross or circle) the most appropriate one
    b. Give check on [ ], for appropriate lists.
    c. Line _______________, for text writing (if needed)

RESPONDEN'S IDENTITY

1. Gender: A. Male, B. Female
2. Working in this school since : _______________
3. Higher Achieved Academic Degree:
   A. Master/Doctorate, B.Bachelor, C.Diploma, D.Secondary School, E. Others
   Field of Academic Degree:
   A. Education (For example: S.Pd, M.Pd, A.Md.Pd),
   B. Science (For example: S.Si, M.Si)
   C. Engineering or Computer (For example: S.T, S.Kom, M.T, M.Kom),
   D. Economic or Social (For example: SE, S.Sos, M.Hum)
   E. Others
4. Number of Training sessions related to technology and computer for education:
   A. More than 5 times, B.3 to 5 times, C.1 to 2 times, D. Never participation, E. Not interested

A. ICT Facilities and Infrastructures

1. Computer and Internet Facilities in School

1.1 Is there any computer laboratory in your school? A. Yes, B. No
If you answer Yes, have you use it for mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
Topic:____
B. Yes, 3 to 5 times per month.
Topic:____
C. Yes, 6 to 10 times per month.
Topic:____
D. Yes, more than 10 times per month.
Topic:____
E. No. Because:
____

1.2 Is there any notebook or projector in your school? A. Yes, B. No
If you answer Yes, have you use it for mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
Topic:____
B. Yes, 3 to 5 times per month.
Topic:____
C. Yes, 6 to 10 times per month.
Topic:____
D. Yes, more than 10 times per month.
Topic:____
E. No. Because:
____

1.3 Is there any internet access in your school? A. Yes, B. No
If you answer Yes, have you use it for mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
Topic:____
B. Yes, 3 to 5 times per month.
Topic:____
C. Yes, 6 to 10 times per month.
Topic:____
D. Yes, more than 10 times per month.
Topic:____
E. No. Because:
____

1.4 Is there any official website or blog about your school? A. Yes, B. No

If you answer Yes, have you and your students accessed it and used it as a source of information?

A. Yes, 1 to 2 times per month
B. Yes, 3 to 5 times per month.
C. Yes, 6 to 10 times per month.
D. Yes, more than 10 times per month.
E. No. Because:

____
____

If you answer Yes (option A, B, C, or D), please give more explanation about your school's website or blog (for example: web address, how to use it, who manages it)?

____
____
____
____

1.5 Is there any special ICT staff in your school? A. Yes, B. No
If you answer Yes, how many times he/she present in your school?

A. 1 to 2 times per week.
B. 3 to 5 times per week.
C. Everyday
D. No specific schedule.

1.6 Do you have an access to internet at school using your hand phone?
A. Yes, B. No
If you answer Yes, how many times in one day you access internet using your hand phone?

A. 1 to 2 times per day
B. 3 to 5 times per day
C. More than 5 times per day
D. Never.

1.7 Do you have additional information to explain related to ICT Facilities and Infrastructures in your school? (Maybe related to its usefulness, problems, etc). Please write it below

____
____
____

2. ICT Facilities and Infrastructures in Teacher's Home

2.1 Is there any computer in your home? A. Yes, B. No
If you answer Yes, have you use it to prepare mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
Topic:____

B. Yes, 3 to 5 times per month.
   Topic:____
C. Yes, 6 to 10 times per month.
   Topic:____
D. Yes, more than 10 times per month.
   Topic:____
E. No. Because:
   ____

2.2 Is there any printer or scanner in your home? A. Yes, B. No
If you answer Yes, have you use it to prepare mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
   Topic:____
B. Yes, 3 to 5 times per month.
   Topic:____
C. Yes, 6 to 10 times per month.
   Topic:____
D. Yes, more than 10 times per month.
   Topic:____
E. No. Because:
   ____

2.3 Do you have an internet access in your home? A. Yes, B. No
If you answer Yes, have you use it to prepare mathematics teaching and learning?

A. Yes, 1 to 2 times per month.
   Topic:____
B. Yes, 3 to 5 times per month.
   Topic:____
C. Yes, 6 to 10 times per month.
   Topic:____
D. Yes, more than 10 times per month.
   Topic:____
E. No. Because:
   ____

2.4 Do you have a personal website or blog? A. Yes, B. No
If you answer Yes, have you used it for course delivery to your students or as a source of course information?

A. Yes, once.
B. Yes, rarely.
C. Yes, sometimes.
D. Yes, always.
E. No. Because:
   ____
   ____

If you answer Yes (option A, B, C, or D), please give more explanation about your personal website or blog (for example: web address, how to use it, who manages it)?

____
____
____
____

2.5 Do you have a member of family or friend who can help you using ICT facilities in your home? A. Yes, B. No
If you answer Yes, how many times does this person help you with your ICT in your home?
A. Everyday
B. 3 to 5 times per week.
C. 1 to 2 times per week.
D. No specific schedule.

2.6 Which software do you frequently use and familiar with?
[ ] a. Specialized Educational Software, name of software:
____
[ ] b. Word Processor (for example: MS Word), you use it to:
____
[ ] c. Presentation (for example: Power Point), you use it to:
____
[ ] d. Spreadsheet (for example: MS Excel), you use it to:
____
[ ] e. Music and Video related software, name of software:
____
[ ] f. Game, name of software:
____
[ ] g. Others, name of software:
____

2.7 Do you have an access to internet using your hand phone in home?
A. Yes, B. No
If you answer Yes, how many times in one day you access internet using your hand phone in home?
A. More than 5 times per day
B. 3 to 5 times per day
C. 1 to 2 times per day
D. Never.

2.8 Do you have additional information to explain related to ICT Facilities and Infrastructures in your home? (Maybe related to its usefulness, problems, etc). Please write it below

____
____

B. Technology-Supported Mathematics Learning Experiences

1. Mathematical Learning Resources

1.1 Would you explain about how students used mathematics learning resources in your class:

____
____
____
____
____

1.2. What are types of learning resources which are used by students in your school:

[ ] a. Printed materials, for example:
____

[ ] b. Physical Media, for example:
____

[ ] c. Digital files, for example:
____

[ ] d. VCD/DVD, for example:
____

[ ] e. Softwares, for example:
____

[ ] f. Game, for example:
____

[ ] g. Others, for example:
____

1.3. What is your opinion about the use of mathematical learning resources through technology-supported mathematics learning experiences in your school:

A. It is possible
B. Possible, but difficult to be implemented
C. It is impossible

Explanation:

____
____
____

1.4. What are problems which would be occur related to above implementation:

[ ] a. Supporting facilities:
____

[ ] b. Teachers' skills:
____

[ ] c. Students' skills:
____

[ ] d. Education system:
____

[ ] e. Time:
____

[ ] f. Others, for example:
____

1.5. Have you created or modified mathematical learning resources?:

A. Yes. Topic:
____

Explanation:
____
____
____
____

B. No. Why:
____
____
____

1.6. Have you ever shared mathematical learning resources your created? A. Yes, B. No

If you answer Yes, please provide an example:
____

2. Learning Designs

2.1 Please explain how you design learning experiences for your class:
____
____
____
____
____

2.2 How other teachers and you share the design of learning experiences?
____
____
____
____
____
____

2.3 Can you use other teachers's design of mathematics learning experiences or do others use your design of learning experiences?

a. If you can, what makes them shareable?
____

b. If not, why not?

____

2.2. What is your opinion about designing learning experiences and its practice through internet or on line platform:

A. It is possible
B. Possible, but difficult to be implemented
C. It is impossible

Explanation:

____
____
____

2.3. What are problems which would be occur related to above implementation:

[ ] a. Supporting facilities:
____

[ ] b. Teachers' skills:
____

[ ] c. Students' skills:
____

[ ] d. Education system:
____

[ ] e. Time:
____

[ ] f. Others, for example:
____

2.4 Have you initiated development of design of mathematical learning experiences through internet or on line platform?

A. Yes. Topic:
____

Description of activities or experience:
____
____
____
____

B. No. Why:
____

2.5. Do you have resources to share related to designing mathematical learning experiences and its practice through internet or on line platform in your school?

Example:
____
____

Please take 1 to 2 minutes to review your answers in this questionnaire.

Thank you for your participation. Information from you will be useful to get comprehensive understanding about implementation of technology-supported mathematical learning experiences, in particular Mathematical Learning Resources and Learning Designs, in developing countries.

☐ **Interviewed** ☐ **Not Interviewed**

APPENDIX V. GUIDELINE FOR INTERVIEW USED IN OBSERVATION

HREC Approval Number: HE10/310

GUIDELINE UNSTRUCTURED INTERVIEW

A. ICT Facilities and Infrastructures

1. Computer and Internet Facilities in School
   - Computer-based teaching and learning of mathematics in the school
   - The use of internet on teaching and learning of mathematics in the school
   - Condition of computer and internet access

2. ICT Facilities and Infrastructures in Teacher's Home
   - How teachers using their own ICT facilities in the home to support their job in the school
   - How many time teachers can spend to use computer and internet to support students' learning experiences

B. Technology-Supported Mathematics Learning Experiences

1. Mathematical Learning Resources
   - Make a documentation of learning resources created by teachers and how it can be used by students
   - How teachers share their own learning resources to others

2. Learning Design
   - Make a documentation of design of learning for mathematics created by teachers
   - How teachers share their own learning design to others

C. Identify ways in which teachers may wish to develop with ICT and teaching resources

APPENDIX VI. HUMAN RESEARCH ETHIC COMMITTEE (HREC) APPROVAL LETTER

UNIVERSITY OF WOLLONGONG

RENEWAL APPROVED
In reply please quote: HE10/310

9 August 2012

Dr Anne Porter
Room 15.113
School of Mathematics and Applied Statistics
University of Wollonong NSW 2522

Dear Dr Porter

Thank you for submitting the progress report. I am pleased to advise that **renewal** of the following Human Research Ethics application has been **approved**.

Ethics Number:	HE10/310
Project Title:	Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries
Researchers:	Dr Anne Porter, Maman Fathurrohman
Date Approved:	9 August 2012
Renewed From:	31 July 2012
New Expiry Date:	30 July 2013

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.

This certificate relates to the research protocol submitted in your original application and all approved amendments to date. Please remember that in addition to completing an annual report the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

Yours sincerely

A/Professor Garry Hoban
Chair, Social Sciences
Human Research Ethics Committee

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

APPENDIX VII.PHOTO DOCUMENTATIONS OF OBSERVATION

Area of Bojonegara Sub District , Banten Province, Indonesia





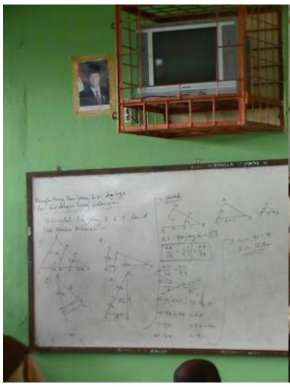



Schools condition in Bojonegara Sub District , Banten Province, Indonesia

- Computer labs

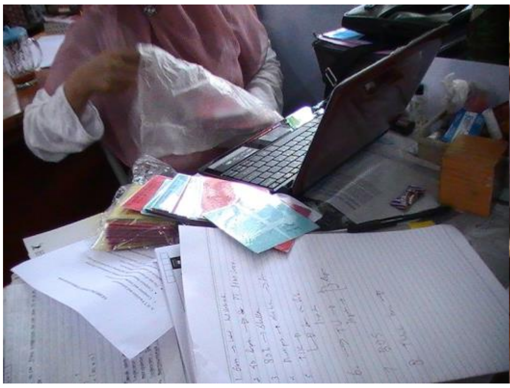



- Classes




- Offices


SINAR DUNIA
High Power




zyrex

- Schools’ Environment







APPENDIX VIII. SAMPLE TRANSLATION OF INTERVIEW TRANSCRIPTS OF OBSERVATION

Place: SDN 1 Bojonegara

Duration: 12 minutes

MF : Maman Fathurrohman
T1 : Teacher 1
T2 : Teacher 2

MF : Would you allow me to know about your name and how long you have been teachers in this school?
T1 : My name is Khadijah (pseudonym). I have been teacher in this school since year 2008
T2 : My name is Fatma (pseudonym). I have been teacher in this school since year 2006
MF : Would you allow me to know about your position in this school?
T1 : My position is teacher of grade 5th Class A. I have been teacher in this school since year 2008
T2 : My position is teacher of grade 5th Class B. I have been teacher in this school since year 2006

Note: according to head of school, in this school, usually each class teachers have a duty to teach all subjects, including mathematics, in their own class. There are two parallel classes in this school for each grade, for example Grade 5th class A and Grade 5th class B. Each class consists of 32 to 40 students.

MF : Would you allow me to know about condition of computers or internet in this school?
T1 : There are three unit computers in this school. But we have no internet connection
MF : Are the available computers can be used for teaching and learning?
T1 : For some occasion, teachers use their own laptop and projector.

Note: T1 usually bring her own laptop to school, but not all teachers do this thing. Several months ago she was awarded Guru Berprestasi (High Achievement Teacher), one of teachers' competition held by Education Office (Province)

T1 : I usually use the internet to get (additional) learning resources, usually in format movies or pictures.
T2 : For the internet connection, students usually use internet café to access internet.
T1 : Usually they do it to open their facebook account or (just for fun).

Note: According to head of school, they had paid around IDR 3,000,000 (equal to AUD 300) to have internet connection in their school. However until the day of interview it still can't be realized.

MF : As we know, handphone also can be used to have connection to internet. According to your knowledge, how many percentages of teachers in this school that can do that?
T1 & T2 : maybe around 30%

MF : Do teachers in this school have their own laptop?
T2 : Some of teachers. But maybe not all of them

Head of School: maybe from 16 teachers, there are 4 teachers who have their own laptop (the head of school was around the place of interview when it undertaken, so she heard, and sometime responded to the discussion)

MF : How if there is a problem with computer, printer, or other ICT Tools in this school is it solved?
T2 : We have no computer technician; however we usually call some technicians from computer services shop to repair it (if needed).

MF : I think computers in this school also can be used for administration purposes.
T2 : Yes. For administration, usually computers are useful.
MF : Do teachers have their own computer in their home?
T2 : Yes. However for me, I usually not operated it (note: her children or family who usually use it).

MF : Is your computer at home is equipped with internet connection?

T2 and T1: Yes
MF : So you or your family do not need to go to internet café to have internet connection?
T2 : Yes.

MF : Do you have an experience in creating learning resources using your own computers and internet at home?
T1 : Yes. I created learning resources in natural sciences at topics: solar system.
MF : What is the format or type of your learning resources?
T1 : Like slide or some like it.

Note: T1 explained that she is sometime downloading videos or pictures from internet to be used on class (or for own purposes). She also explained her learning resources are not used by other teachers (only for herself).

MF : How were students' reactions when you use these learning resources?
T1 : They are interested and attracted to it.
T2 : Students are interested.

MF : What is role of ICT on your own learning design?
T2 : Yes, ICT should be considered however at this time we usually do not including it in our learning design.

MF : I want to know, has this school received ICT grant or facilities from companies or other organizations?
T1 : As long as I know, we received grants two times, that computer (at background) and other.
T1 : We also received CD of learning resources

MF : How with BSE (Buku Sekolah Elektronik)? also used in this school? I mean the PDF version?
T1 : I did not know, maybe not.

Note: I saw that teachers (not only in this school but also in other schools) were not familiar with PDF versions of electronic school books that are supplied by Ministry of National Education.

MF : Do you want to say something related to ICT for Education?

T1 explained that she hope ICT can be implemented in Education, not only by particular or several teachers but also by the majority of teachers in her school. She was sure that it will interest and motivate students, and it will increase students' learning outcome.

HREC Approval Number: HE10/310

English Translation

APPENDIX IX. TRANSLATION OF INFORMATION SHEET USED IN LOCALISED AND CASE STUDIES RESEARCH

University of Wollongong

PARTICIPATION INFORMATION SHEET

Maman Fathurrohman
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Associate Professor Anne Porter
School of Mathematics and Applied Statistics
Phone: (+61) 24 221 4058
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Dear Teachers,

This is an invitation for you to participate in a study conducted by researchers at the University of Wollongong. The research is called ***Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries***. The purpose of this collaborative research is to get view, advice, evaluation from teachers based on their knowledge and experience about the products developed during this research project.

Teachers are asked to install and use the products provided by researcher, including integrating the use of these products to their daily activities in mathematics teaching and learning. After that teachers are asked to fill in questionnaire to express their satisfaction and evaluation to these products. Teachers also will be interviewed to discuss about their opinion and experience about the products.

Participation is not compulsory. You are free to decide if you want to be involved in this project or not. You can withdraw your permission to participate at any time. The final published results of the research will be aggregated measures and there will be no features that could lead to the identification of individual teacher.

Participation in this research is valuable as you can help the improvement of the mathematics learning experience through technology-supported learning resources and learning designs adapted for schools in developing countries.

If you have any concerns or complaints as to how the research is conducted you should contact the Secretary of the University of Wollongong Human Research Ethics Committee on (+61) (02) 4221 4457.

Thank you in anticipation of your willingness to participate.

APPENDIX X. TRANSLATION OF CONSENT FORM USED IN LOCALISED AND CASE STUDIES RESEARCH

HREC Approval Number: HE10/310	English translation

University of Wollongong

Consent Form

Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries

Researchers:
Assoc Professor Anne Porter and Maman Fathurrohman

Please return the following statements to indicate your agreement to participate:

- I agree to give permission to use my comments for this research
- I agree to be contacted for further questions if they arise.
- I agree to give permission to analyse my satisfaction and evaluation of products in relation to the research project Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries.

By signing below I am indicating my consent to participate in the research. I understand that my results will not identify me personally in any subsequent publication.

Signed Date

……………………………………… ……./……./ 2011

Name

………………………………………

APPENDIX XI. TRANSLATION OF QUESTIONNAIRE FORM USED IN LOCALISED AND CASE STUDIES RESEARCH

University of Wollongong

HREC Approval Number: HE10/310

English translation

QUESTIONNAIRE

Contact:
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Email: alp@uow.edu.au

Title:
Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries

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Explanation:
Purpose of this questionnaire is to gain view, advice, evaluation from teachers based on their knowledge and experience about the product developed during this research project. This questionnaire is accompanied with CD Software and other related documentations

How to answer the questions:
Choose A, B, C, D, or E to the most appropriate answer
Choose one of possible answers (From Very Satisfied to Not Satisfied or Strongly Agree to Strongly Disagree) to the most appropriate answer
Line _______________, for text writing (if needed)

RESPONDEN IDENTITY
1. Name of Teacher: ____
2. Gender: A. Male, B. Female
3. Class: ____
4. At School or Class, Using Computer:
   Yes: A. Teacher Owned, B. School Owned
5. Type: A. Computer Notebook, B. Tablet PC, C. Desktop PC, D. Netbook, E. Other
   Operating System: A. Windows, B. iOS, C. Android, D. Linux, E. Other

A. Electronic Maps

Electronic Map of Learning Resources

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	File Structure					
3	Features					
	Database Structure					
	Entry Data					
	Modifiable and Shareable					
4	Function					
5	Innovation					
6	Capability					

Electronic Map of Learning Designs

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	File Structure					
3	Features					
	Designing Curriculum-Aligned and Non Curriculum-Aligned Learning Design					
	Converting to HTML to be Accessed via Internet					
	Modifiable and Shareable					
4	Function					
5	Innovation					
6	Capability					

B. Systems

Electronic Mapping System of Resources in the Internet

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	Design					
3	Features					
	Reading Electronic Maps					
	Catalogue and Searching Facilities					
	One Button Click (The use of one button by click it to visit Web Site)					
4	Function					
5	Innovation					
6	Capability					

Electronic Mapping System of Learning Designs

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Idea					
2	Design					
3	Features					
	Reading Electronic Maps					
	Using XML Technology					
	Recording Learning Design					
4	Function					
5	Innovation					
6	Capability					

Implementation in School or Classroom

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Friendly and Easy to Use					
2	Appropriate to Current ICT Condition					
3	Beneficial					
	For Teachers					
	For Students					
	For Schools					
	For Education Office					
4	Institutionalization					
	Implementable					
	Has A Good Impact					
	Maintenance of Product by Teachers or Schools					

Comment:
___
___
___
___
___
___
___

Relation to Curriculum

No	Components	Evaluation				
		Very Satisfied	Satisfied	Somewhat Satisfied	Slightly Satisfied	Not Satisfied
1	Prototype as a Tool Related to Curriculum Development					
2	Prototype as a Tool to Documents Resources and Learning Design					
3	For Electronic Map Aligned to Curriculum					
	Synchronization of Curriculum to Electronic Maps					
	Easy to Create Electronic Maps					
	Easy to Share Teachers Own Electronic Maps					
4	For Electronic Map Not Aligned to Curriculum					
	Allowing Teachers to Create Their Own Curriculum for A Special Teaching					
	Easy to Create Electronic Maps					
	Easy to Share Teachers Own Electronic Maps					

Appropriateness for Use in Developing Countries

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Appropriate for Teachers					
2	Appropriate to Current ICT Condition					
3	Could be Implemented in Developing Countries					
4	Could be Institutionalized in the Schools					

5	Recommended to be Used by Other Teachers.					

Future Development

No	Components	Evaluation				
		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	Has a Good Potential for Development and Implementation					
2	Recommended to be Used in Developed Countries (not only in Developing Countries)					
3	Recommended to be used in Other Subjects (not only in Mathematics)					
4	Recommended to be Available in Other Platforms (not only in Windows)					
5	Has a Good Prospect for Patent and Commercialization					

Comment:

____

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____

____

Date, ____________________

Teacher

____

APPENDIX XII. GUIDELINES FOR INTERVIEW USED IN LOCALISED AND CASE STUDIES RESEARCH

University of Wollongong

HREC Approval Number: HE10/310	English translation

INTERVIEW

Name: ___________________, Position: __________________________

These systems enable teachers to create their own electronic maps.

1) Electronic map of mathematical learning resources in the Internet provides a great access to learning resources accessible through Internet
2) Electronic map of mathematical learning design documents teaching and learning experiences. This type of map preserves the design of mathematical teaching and learning thus enable the design to be accessible by other parties (students, other teachers, head master, etc)

Imagine the condition where teachers could create their own electronic maps. At this condition, good and high quality selected electronic maps could be useful for other teachers. Through the sharing of these maps, quality of mathematical teaching and learning could be improved. Since these maps are intellectually created by human, it will be different from those created artificially by machine or computer. In the special case, some of the maps could be valuable, thus eligible to be sold or for commercialization.

Following is list of questions.

1. If you have a capability to create an electronic map, what is the title of electronic map that do you want to create?

____
____
____
____
____

2. In your opinion, how is the electronic map could be used to support teachers on conducting mathematical teaching and learning?

____
____
____
____
____

3. In your opinion, how to maintenance the use of electronic maps and its associated systems for a long term, How good is it prospect to be institutionalized in your school?

____
____
____
____
____

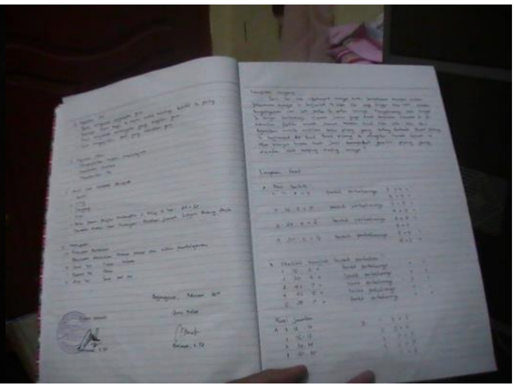
4. Do you have any advice or suggestion to make this product better?

____
____
____
____
____

APPENDIX XIII. PHOTO DOCUMENTATIONS OF LOCALISED AND CASE STUDIES RESEARCH

- Demonstration

- Implementation

- Discussion



APPENDIX XIV. LIST OF PRE- AND POST-TESTS QUESTIONS FOR EMPIRICAL STUDY

No	Topic: Number		Topic: Function		Topic: Graphic	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
1	Explain the history of number system as you know!	Explain how number system has evolved from ancient civilization to present!	f(x) = x +5, g(x) = x+2 Calculate: f(x) o g (x)	f(x) = x^2+ x + 1, g(x) = - x^2+ x – 1, h(x) = x^2- x + 1 Calculate: f(x) + g (x) - h(x)	Draw graphics of y=x+5	Draw locations of these points in Cartesian coordinate, then measure the length of A to C A(1,2), B(3,4), and C(5,6)
2	What is natural number?	Explain what is natural and rational number? Give an example!	f(x) = x^2+x+2 g(x) = x+1 Calculate: f(x) o g (x)	Use f(x), g(x), and h(x) from previous question, Calculate f(x) o g(x) and g(x) o h(x). Is f(x) o g(x) = g(x) o f(x)?	Draw graphics of y=x^2+x+2	Draw locations of these points in Cartesian coordinate, then measure the length of A to C A(1,2,3), B(4,5,6), dan C(7,8,9)
3	Calculate $\frac{1}{2} x \frac{1}{2} \div \frac{1}{4} - \frac{1}{4}$	Calculate $\frac{1}{5} + \frac{1}{3} - \frac{2}{5} x \frac{1}{4} \div \frac{20}{2}$	f(x) = x + 5 Show the value of function for x = 8 through its graph	If y(x) = a Sin (x), and z(x) = b Cos (x) Give an exact value or requirement of a, b, and x such that y(x)=z(x), show through its graph	Draw graphics of function y(x) = x^2-4	Draw graphics of function y (x) = x^2 + x + 1
4	Find the value of number (n) |n+3|=8	Calculate $\sqrt{2^2 x 2^2}$	f(x) = x^2+x+2 Show the value of function for x = 8 through its graph	If y(x) = a + Sin (x), and z(x) = b + Cos (x) Give an exact value or requirement of a, b, and x such that y(x)=z(x), show through its graphs	Draw graphics of function y(x) = x^2+2	Draw graphics of function y(x) = 2 Sin (x) + 1

APPENDIX XV. PARTICIPANT INFORMATION SHEET USED IN CURRICULUM REVIEW

HREC Approval Number: HE10/310

University of Wollongong

PARTICIPANT INFORMATION SHEET

A/P Anne Porter[1], A/P Annette L Worthy[2], Maman Fathurrohman[3]
School of Mathematics and Applied Statistics
Phone: (+61) 24 221 4058
Email: [1]alp@uow.edu.au, [2]annie@uow.edu.au, [3]mf704@uowmail.edu.au

Dear Member of University of Wollongong Staff

We are engaged in a research project, entitled *Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries*. It has entailed creating software that can be use for mapping learning designs to facilitate the sharing of resources and for subsequent use in curriculum reviews. We are currently in stage of improving the usability of our mapping tool. To achieve this purpose, would like to learn from other people about their experiences with subject outline templates, curriculum mapping, curriculum review, and mapping learning designs.

We would like to invite you to participate in an interview in regard to your experiences with subject outlines templates, curriculum mapping and review tools and the mapping learning designs. This interview should help us improve the usability of learning design mapping tools (objectives, tasks , resources and supports) for the purposes of curriculum review.

In our meeting we would like to pose three sets of questions:

1. Can you tell us about your experience with subject outline templates, curriculum mapping and review tools, and learning design mapping tools and the processes for using the same? What are the essential qualities of such tools or processes for effective use of them?
2. Have you encountered any issues with existing templates or the processes for using them? What features makes them work, or what features are missing for the work you do?
3. How do you think we can best combine the use of subject outlines, maps of learning design and curriculum?

At the end our meeting, if you wish, we can show you about how the learning designs map can be use for curriculum mapping and we would invite comment as to how it can be improved.

Participation is not compulsory, but encouraged because the result will be benefit for many educators and educational institutions for the implementation of mapping learning design for use in curriculum review. The final published results will be reporting under pseudonyms, except if you agree that we are allowed to state that we have interviewed you in regard to this topic for publications (papers and PhD thesis).

If you have any concerns or complaints as to how the research is conducted you should contact the Secretary of the University of Wollongong Human Research Ethics Committee on (+61) (02) 4221 4457.

Thank you in anticipation of your willingness to participate.

APPENDIX XVI. CONSENT FORM USED IN CURRICULUM REVIEW

HREC Approval Number: HE10/310

University of Wollongong

School of Mathematics and Applied Statistics

Consent Form

Creating and Modifying Mathematical Learning Resources and Learning Designs for Use in Developing Countries

Topic: Increasing the Usability of Learning Design Form (LDForm), Learning Design Map (LDMap), and Learning Design-based Curriculum Reviewer (LDCR) for Curriculum Review

Researchers:
Assoc Professor Anne Porter, A/P Annette L. Worthy, Maman Fathurrohman,

Please return the following statements to indicate your agreement to participate:

YES / NO • I agree to give permission to use my comments for this research

YES / NO • I agree to be contacted for further questions if they arise.

YES / NO • I agree to give permission to researchers to state in publication that they have interviewed or gave comment to this research (including my name, academic degree and position in the publications).

YES / NO • I agree to give permission that interview record, video, photos or artefacts (copies of resources) will be used at conference/ seminar presentation

By signing below I am indicating my consent to participate in the research. I acknowledge that the final published results will be reporting under pseudonyms

Signed ……………………………………… Date ……./……./ ....

Name

………………………………………