A MOBILE LEARNING OBJECTS COMPILATION FRAMEWORK BASED ON SEMANTIC WEB AND RANDOM FOREST

ROGERS PHILLIP BHALALUSESA

UNIVERSITI SAINS MALAYSIA
2017

A MOBILE LEARNING OBJECTS COMPILATION FRAMEWORK BASED ON SEMANTIC WEB AND RANDOM FOREST

by

ROGERS PHILLIP BHALALUSESA

Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy

FEBRUARY 2017

Declaration

Name: Rogers Phillip Bhalalusesa

Matric No: PCOD-0004/12 (R)

School: Computer Science

Thesis Title: A mobile learning object compilation framework based on semantic web and random forest

I hereby declare that this thesis I have submitted to School of Computer Science on ..... is my own work. I have stated all references used for the completion of my thesis. I agree to prepare electronic copies of the said thesis to the external examiner or internal examiner for the determination of amount of words used or to check on plagiarism should a request be made.

I make this declaration with the believe that what is stated in this declaration is true and the thesis as forwarded is free from plagiarism as provided under Rule 6 of the Universities and University Colleges (Amendment) Act 2008, University Science Malaysia Rules (Student Discipline) 1999.

I conscientiously believe and agree that the University can take disciplinary actions against me under Rule 48 of the Act should my thesis be found to be the work or ideas of other persons.

Students Signature: ..... Date: .....

Acknowledgement of receipt by: ..... Date: .....

ACKNOWLEDGEMENT

There are so many people and groups that have supported my research journey. I would like to take this opportunity to thank each one of them for the roles they played in the course of my research.

First and foremost I would like to take this opportunity to thank and appreciate my supervisor Associate Professor Muhammad Rafie Hj Mohd Arshad for the expertise and guidance he provided to me which has allowed me to complete my research successfully.

Apart from that I am grateful for the university administration of School of Computer Sciences and the Management of Universiti Sains Malaysia for giving this opportunity to conduct the research at their institution and gave me all the administrative and financial support that I required in order to finish the research study.

A lot of thanks go to the Open University of Tanzania Management for giving me study leave and financial support to undertake the PhD studies. The overall assistance that they provided to me, helped me a lot to concentrate in this research study.

Last but not least I would like to express my gratitude to my family for being there for me throughout the whole journey of conducting this PhD research. My wife and daughter gave me inspiration to work hard and be able to finish the research study.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ACRONYMS

ADL	Advanced Distributed Learning
ALOCoM	Abstract Learning Object Content Model
CanCore	Canadian Core Application Profile
CC	Creative Commons
DC	Dublin Core
DCMI	Dublin Core Metadata Initiative
DLCMS	Dynamic Learning Content Management System
DT	Decision Trees
E-Learning	Electronic Learning
FOAF	Friend Of A friend
GA	Genetic Algorithm
HTTP	Hypertext Transfer Protocol
ICT	Information Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
iOS	Apple Operating System
JSON	JavaScript Object Notation
KB	Knowledge Base
kNN	K Nearest Neighbours
TPACK	Technological Pedagogical Content Knowledge
LMS	Learning Management System
LO	Learning Object
LOM	Learning Object Metadata
LTSC	Learning Technology Standards Committee

MeLU	Meaningful E-learning Units
MERLOT	Multimedia Education Resources for Learning and Online Teaching
MIT	Massachusetts Institute of Technology
M-Learning	Mobile Learning
MLOC	Mobile Learning Object Compilation
MOLENET	Mobile Learning Network
MoLODUF	Mobile Learning Objects Deployment and Utilisation Framework
Moodle	Modular Object-Oriented Dynamic Learning Environment
MSSQL	Microsoft Server Query Language
MYSQL	My Server Query Language
NN	Neural networks
NV	Naive Bayes
OER	Open Education Resources
OERCOMMON	Common Open Education Resources
OUM	Open University of Malaysia
OWL	Ontology Web Language
OWL + DL	Ontology Web Language Description Logic
OWL FULL	Full Ontology Web Language
OWL Lite	Lite Ontology Web Language
PASER	Planner for the Automatic Synthesis of Educational Resources
PHP	Hypertext Pre-processor
PIF	Package Interchange File
POSTGRESQL	Post-gress Query Language

RDB	Relational Database
RDB2RDF	Relational Database to Resource Description Framework
RDF	Resource Description Framework
REST	Representational State Transfer
RF	Random Forest
RLO	Reusable Learning Object
SCO	a Sharable Content Object
SCORM	Sharable Content Object Reference Model
SMS	Short Message Service
SOAP	Simple Object Access Protocol
SPARQL	Simple Protocol and RDF Query Language
SQL	Structured Query Language
SVM	Support Vector Machines
SWmLOR	Semantic Web Mobile Learning Object Repository
SWRL	Semantic web rule language
TBox	Terminology Box
TMDC	Teaching Material Development Centre
UNISA	University of South Africa
URI	Universal resource Identifier
US	United States
WEBCT	Web Course Tool
WSDL	Web Service Description Languages
XML	Extensible Mark-up Language

RANGKA KERJA PENGUMPULAN OBJEK PEMBELAJARAN MUDAH ALIH BERASASKAN WEB SEMANTIK DAN "RANDOM FOREST"

ABSTRAK

Pembelajaran mudah alih adalah satu bidang yang menggunakan peranti mudah alih untuk mengakses kandungan pembelajaran dan mengendalikan aktiviti pembelajaran. Malangnya sebahagian besar daripada institusi - institusi tidak mempunyai kandungan pembelajaran yang boleh digunakan dalam peranti mudah alih. Membangunkan kandungan pembelajaran mudah alih adalah sukar dan oleh itu teknik penggunaan semula objek pembelajaran dalam talian biasanya dilaksanakan. Walau bagaimanapun, ianya memerlukan para pendidik menghabiskan masa yang lebih lama dan mempunyai kemahiran komputer yang tinggi untuk mencari Objek Pembelajaran Gunasemula (RLO) dalam talian dan oleh yang demikian ramai para pendidik gagal untuk mendapatkan kandungan pembelajaran yang berkaitan. Bagi memudahkan proses ini, web semantik boleh digunakan untuk mencari, mendapatkan semula dan menggabungkan RLO menjadi suatu kandungan pembelajaran mudah alih. Untuk melaksanakannya, web semantik perlu mendapatkan metadata RLO, menilai RLO berdasarkan metadata dan menggabungkan RLO berkaitan. Cabaran yang dihadapi apabila menggunakan web semantik adalah, pertama tidak semua objek pembelajaran dalam talian adalah berkesan untuk peranti mudah alih, kedua, objek metadata pembelajaran tidak mudah diperolehi dan akhir sekali enjin inferens web semantik adalah perlahan dalam menilai RLO menggunakan peraturan transitif. Satu rangka kerja Pengumpulan Objek Pembelajaran Mudah alih (MLOC) dicadangkan dalam penyelidikan ini dengan menggunakan web semantik untuk menyelesaikan cabaran-cabaran tersebut supaya ianya dapat digunakan secara efektif

untuk penggunaan semula objek pembelajaran. Rangka kerja hibrid ini merangkumi kaedah untuk menjana metadata RLO dari repositori, penggunaan metadata tersebut untuk menilai RLO, penggabungan RLO berkaitan untuk membentuk RLO lebih besar dan membenarkan capaian kandungan pembelajaran ini kepada sistem lain di luar melalui perkhidmatan web supaya aplikasi mudah alih boleh mengakses RLO dengan mudah. Oleh itu, penyelidikan ini mengkaji kaedah yang boleh menambah baik web semantik dalam penggunaan semula objek pembelajaran untuk peranti mudah alih. Pertamanya, penyelidikan ini akan memperkenalkan kaedah untuk menjana metadata pembelajaran daripada hasil carian awam berasaskan teori-teori pembelajaran. Kedua, penyelidikan ini akan mengujudkan kaedah semantik untuk menilai RLO dan menggabungkan RLO menjadi unit pembelajaran lengkap dalam repositori yang boleh diakses oleh peranti mudah alih. Akhir sekali, penyelidikan ini akan menambah baik penilaian semantik RLO dengan menggunakan kaedah "Random Forest". Dengan perlaksanaan tersebut, penyelidikan ini akan meningkatkan akses kepada kandungan pembelajaran dan metadatanya disamping meningkatkan keupayaan inferen web semantik. Penilaian dilaksanakan dengan menguji prototaip yang dibangunkan berasaskan rangka kerja hibrid. Hasil penilaian menunjukkan bahawa rangka kerja yang dicadangkan boleh menjana metadata objek pembelajaran yang efektif dan menggunakannya untuk menilai serta menggabungkan RLO secara efektif dengan ketepatan sekitar 98%. Kerangka kerja yang dicadangkan juga berupaya untuk mencari dan mendapatkan semula RLOs dengan lebih efisyen berbanding dengan kaedah dapatan semula RLOs oleh aplikasi mudah alih yang berkaitan, yang mana membuktikan bahawa MLOC boleh digunakan untuk memproses objek pembelajaran gunasemula untuk peranti mudah alih.

A MOBILE LEARNING OBJECT COMPILATION FRAMEWORK BASED ON SEMANTIC WEB AND RANDOM FOREST

ABSTRACT

Mobile learning is a field which uses mobile devices to access learning contents and conduct learning activities. Unfortunately most of the institutions do not have learning contents that can be used in mobile devices. Developing mobile learning contents is difficult and therefore the technique of reusing online learning objects is usually employed. To simplify this process, semantic web can be used to search, retrieve and assemble the Reusable Learning Objects (RLO) into mobile learning contents. Among the biggest challenges facing semantic web when processing RLO, are the facts that, first not all online learning objects are effective for mobile devices, second the learning objects metadata are not readily available and the lastly the semantic web inference engine is slower in evaluating the RLO using transitive rules. A Mobile Learning Objects Compilation Framework (MLOC) which is a hybrid framework of random forest and semantic web is proposed by this research to address these challenges so that semantic web to can be used effectively to reuse learning objects. The hybrid framework should include a method to generate RLO metadata from repositories, use those metadata to evaluate the RLO, assemble related RLO to form larger RLO and expose these learning contents to other outside systems through web services so that mobile apps can access the RLO easily. This research therefore examines the methods to enhance semantic web in the reuse of learning objects for mobile devices. The research will first introduce a method to generate learning metadata from public search results based on learning theories. Secondly, the research will establish the semantic methods to evaluate the RLO and

assemble RLO into complete learning units in a repository that can be accessed by mobile devices. Lastly the research will enhance the semantic evaluation of RLO by using Random Forest. By doing so this research will increase access to mobile learning contents and their metadata as well as improve inferencing capabilities of Semantic Web. Evaluation is done by testing a prototype developed by using guidelines from the hybrid framework. The results indicate that the proposed framework can generate learning objects metadata and use them to evaluate and combine RLO with acceptable accuracy of about 98%. The proposed framework is also able to search and retrieve RLOs which are much more efficient compared to RLOs retrieved by other related mobile apps which in turn confirms that MLOC can be used to process reusable learning objects for mobile devices.

CHAPTER 1 : INTRODUCTION

1.1 Background

Reusability is a process within product development lifecycle of software engineering which reduces the production time and resources by using an existing asset within a development of another product. One area that is using software engineering to develop its products is learning systems commonly known as electronic learning (e-learning). In e-learning the digital learning contents are products of software engineering and can be reused in the production of other e-learning contents.

Mobile learning which uses mobile devices such as smartphones and tablets is a part and parcel of e-learning and can re-use e-learning contents (Muyinda, 2010). The learning contents in e-learning are composed of a lot of subject related pieces of information known as learning objects (LO). When the LO are reused in different learning systems they are known as reusable learning objects (RLO).

Due to the limitations of financial and Information and Communication Technologies (ICT) resources, many institutions rely on only lecturers to develop the learning contents on the own without much support from instructional designers and Information Technology (IT) experts. Developing e-learning contents from scratch is difficult and many lecturers take the option of using the RLO found freely on the internet and customize them to fit their students' needs. However many lecturers fail get the effective learning contents to be used in mobile devices (such as lectures, presentation and simulations). This is because not all existing online RLO can be used in mobile learning due to the limitations of mobile devices which include

unavailability of common platform, small screen size, low storage size, processing power and battery life as well as high costs and unpredictable network access (Damaševičius, 2010, McGreal et al., 2005). In turn the lecturers have to search and assemble specific RLOs from the search engines which is not an easy task.

The search tools that are used by lecturers to reuse RLO from internet adopt Semantic Web technologies. Semantic web is the use of artificial intelligence in the web so that the computers can understand the links and the web resources without human interaction. Semantic Web understands the resources through metadata and ontologies. Metadata is the information describing the web resource. In the e-learning context the metadata are called Learning Objects Metadata (LOM). The Semantic web use special dictionaries known as ontologies to understand the metadata and links (Gavriushenko et al., 2015). Resources in the Web such as RLO are stored with metadata in order to make them discoverable by semantic web agents. Ontologies are used to build, organize and update learning contents based on LOM. But the current implementation of these tools is limited to particular function and cannot accommodate all the processes of reusing the online LO which are beyond just connecting the resources.

Some initiatives based on semantic web have been extended to use LOM to organise and assemble RLO into effective learning contents (Mason, 2011). Good examples are the Sharable Content Object Reference Model (SCORM), A Learning Object Content Model (ALOCoM) and CISCO's Reusable Learning Object. SCORM has an advantage compared to the other initiative because it is independent of a particular learning system and therefore has been widely adopted throughout the

whole world (Mason, 2011). However SCORM still has shortcomings to cover modern education technologies including mobile learning (Kavcic, 2011, Mudu et al., 2011). Mobile learning requires special kinds of RLO which cannot be filtered in the current SCORM compatible systems. The RLO need to be small in size, be effectively stored and accessed from the repository using mobile devices applications and contain enough metadata to make them easily reusable further. These features currently lack in SCORM compatible systems which in turn renders the SCORM based RLO not to be effective in mobile learning.

1.2 Motivation of the Study

Semantic web has been successfully applied to search, organise and connect online web resources automatically without human intervention. The ability of semantic webs to use artificial intelligence to connect web resource can be used to counteract the limitations of mobile devices (Rueangprathum et al., 2015). Semantic web can therefore be extended by computer science experts in order to generate RLO suitable for mobile devices and assemble them into effective learning contents automatically. Further through semantic web the LOs can be arranged chronologically based on how the course is supposed to be undertaken. But again getting the semantic web to retrieve and assemble RLO into effective learning contents require careful planning of the whole system. Semantic web works well when ontologies are shared. But in reality ontologies are not shared among the RLO repositories. Each repository stores the RLO in their own ontologies which makes it difficult to combine them using their ontologies. In addition to that the metadata are usually not easily attainable since most of RLO are either not stored with metadata or their metadata are not easily accessible from outside the repositories. That means, if

the semantic techniques in these areas where they fall short, can be strengthened further by computer science expert, then the access and reuse of LO will also be improved.

1.3 Problem Statement

The limitations of mobile devices pose a problem developing and accessing the reusable learning objects in Mobile learning even with the help of Semantic Web. The lack of common platform used by mobile devices requires diverse IT skills to be used when deploying the RLO into Mobile learning. Apart from that, the screen size requires small and effectively engineered RLO to be used in mobile devices. In addition to that the perishable power supply makes it difficult to use the mobile devices for a long time (McGreal et al., 2005, Damaševičius, 2010). This requires the learning contents to be carefully checked before being allowed to be used in mobile learning.

As online repositories contain a variety of learning contents, it important to evaluate the content before retrieving to be used for mobile devices. In addition to that the whole process of retrieving the RLO from online repositories contains many processes, each of which presents difficulties to the users. First, lecturers have to search for RLO from different packages from the internet using search retrieval tools such as Google (Wang and Hsu, 2006). Then after, since not all RLO can be used in mobile devices, the lecturers have to evaluate if the RLO is usable in mobile devices, download the RLO and store it in the local repository. After that the RLO has to be integrated with other RLO based on the learning templates in order to form complete effective learning contents. Since all these tasks are difficult, most of the lecturers

fail to find the RLO suitable for mobile devices using search tools. These processes and the problems they create are summarised in figure 1.

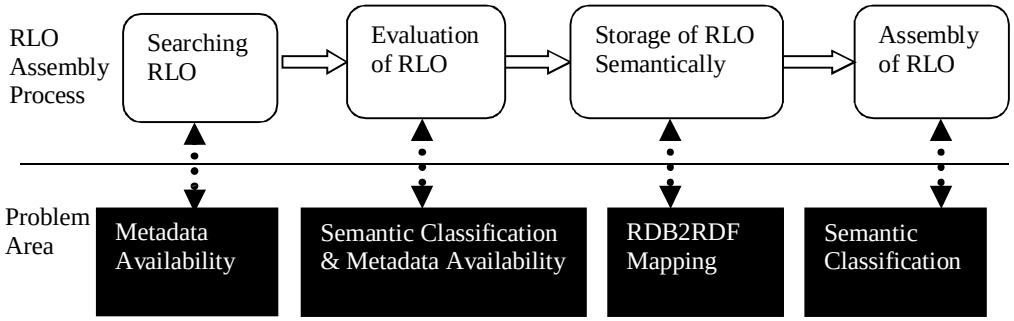

Figure 1: Processes to Retrieve Effective RLO from Online Repositories

The first problem arises by not knowing what type of learning contents (RLO) that can be effective in mobile devices. After knowing the type of effective learning content for mobile devices another problem of downloading the RLO arises. Since mobile devices have limitations especially of sizes and power, it is inefficient to just download all RLOs from the search results. A mechanism has to be put in order to evaluate if the RLO will be effective in mobile devices before downloading. It is difficult to evaluate RLO because most of them are stored in repositories without the proper metadata. Furthermore once the contents have been downloaded the problem of storage of RLO in semantic aware formation comes into focus. The common practice is to store RLO in Relational Database (RDB) (Thuy et al., 2014). But the RDB cannot be shared in semantic web because of the closed nature of the databases and in turn the ontology structure (such as Resource Description Framework (RDF) is required to facilitate the use of these Databases. The effective way to create the ontologies for RLO is to map their RDB into RDF. Mapping the RDB into RDF presents a huge challenge in institutions (Thuy et al., 2014, Salas et al., 2011). The

last part is the fact that the RLOs on their own are not enough to be effective. They have to be combined with other RLOs in order to make them effective as noted by (Santacruz-valencia et al., 2010).

All in all the problem statement can be summarized as the "Assembling of on RLO into effective learning contents for mobile devices using semantic web requires knowing exactly what types of RLOs are effective for mobile devices, searching for those effective RLO for mobile devices in the internet, evaluating if the RLOs are effective and assembling a set of the identified effective RLOs based on their metadata into learning unit in a repository system that can be accessed by mobile devices.

1.4 Research Questions

The research to be undertaken is guided by the following detailed research questions

i. How can effective metadata of RLO for mobile devices be obtained from repositories?
ii. How can RLO be compiled by semantic web and random forest into effective learning contents for mobile devices?
iii. Is Classification Algorithm faster than Transitivity Engine in classification of RLO?

1.5 Thesis Objective

The main objective of the research is to develop a framework based on semantic web to reuse learning objects from online repositories in mobile learning.

The detailed objectives of this thesis can therefore be broken down in the following detailed objectives.

i. Design a method to generate RLO metadata from search tools that can be used to check if RLO is effective in mobile devices in order to assist in evaluation of RLO automatically by the semantic web agents.

ii. Develop a method to compile RLO into effective mobile learning contents by first evaluating if the material is effective and then combining related RLO using semantic web and random forest.

iii. Enhance the classification capabilities of transitive rules of inference engines of semantic web by using Random Forest Algorithm to predict effectiveness of the RLO

1.6 Scope

The RLO that will be considered in the study are those which are used in Higher Learning Institutions. The types of mobile devices that will be considered are those with computation power of smart phones and above (such as IPad, smart phones, laptops etc.). The type of Operating system that the proposed framework will be based on is Android for mobile devices and windows X since these are the most common operating systems. Since formulation of RLO involves many processes some of which are common this study will focus on those processes that are vital to increase the effectiveness of the mobile RLO. These processes are Metadata generation, RLO Evaluation, RLO storage and RLO assembly. The prototype developed also only focuses on the video types of RLO for evaluation and testing of the framework.

1.7 Contribution of the Research

The major contributions of this research is to create the framework to reuse learning objects in mobile devices from online repositories. To arrive to this goal the following detailed contributions will be achieved.

i. Establish a method to generate metadata from search results that can be used by the semantic web agents to evaluate if the RLO is effective in mobile device.

RLO are usually downloaded without enough metadata. This is because the reused RLO are not stored with enough metadata. Usually users just save the RLO they want with the required names without the other important metadata that are used for RLO evaluation such as length, size, course, topic etc. In order to improve the evaluation of RLO these metadata have to be obtained first. This research therefore looks to generate metadata from the search engine and repositories that house RLO in order to use them for RLO evaluation.

ii. Introduce a method of evaluation and assembling RLO for mobile devices using Semantic web and Random forest.

The research introduces the alternate mechanism of getting the best RLO that can be used in mobile devices. The mechanism introduced by this research is a combination of Semantic Web and Random Forest. Semantic Web is used to define and connect the relationship between the RLOs and their templates and the Random Forests algorithm ensures the speed of the semantic web is sufficient to produce timely results.

iii. Improve the semantic method of evaluating RLO using Random Forest classification.

Semantic web makes sure that the RLO are easily connected in heterogeneous systems. Semantic web uses transitive rules in classify RLO as being effective or not. However transitive rules involve many steps which may delay the classification process. By using the Random Forest to classify the RLO in place of transitive rules, the research will increase the speed of Semantic web in general.

1.8 Research Methodology

The problems highlighted above requires solutions to be designed and developed. Such solutions can be achieved from design research (Nieveen and Folmer, 2013). This study therefore employs a design research and its output is a framework for developing learning contents for mobile devices. The framework to be designed and developed by the research is based on the theories of mobile learning and semantic web technologies derived from the past researchers. To achieve such a framework extensive literature review is to be done in the learning theories, mobile devices limitations and the technologies (semantic web and random forest) that can be used in the framework. Evaluation of such a framework is done experimentally by developing a prototype based on the framework and then observing the effects of the sample RLO generated from the prototype. The evaluation of the framework will be based on empirical analysis of RLO obtained from the prototype compared against a control experiment. Hypothesis governing the evaluation will be adopted from the literature review and tested in the experiment to guide the evaluation. The prototype will also be tested based on Black box testing. The testing is done and reported under the IEEE 829-2008 standard with all document reports summarised in a table

(Camargo et al., 2015). The whole research methodology can be described in a research framework.

Since the evaluation of the experimental research is done using empirical analysis then independent and dependent variables have to be identified. Conceptual framework can assist to establish the variables of a research study. From the literature review (section 2.2.3) the independent variable (social economical, pedagogical and technical metadata) are explored and established. The controlled variables will be the type of mobile devices chosen, the type of RLO repositories identified, the type of ontologies to be used and the semantic web technique to map RLO. The dependent variables will be the effective learning content. The independent variables will be fed into the proposed framework together with the controlled variables and the output will be a complete learning contents made of RLO. The learning contents can then be evaluated to see if it contains the metadata that will make it suitable to be used in mobile devices. Figure 2 shows the main identified variables of the study. Based on the figure 2 the independent variables will be passed though the main processes of the proposed framework.

The main processes identified in figure 2 are in line with the main problematic areas of reusing RLO identified in figure 1 but the order of execution changes in order to introduce centralised approach commonly and widely used by centralized web-based learning systems (Chatti et al., 2012). RLO storage has to be initiated first in order to centralise all the processes. In the proposed framework, Database Knowledge Creation which deals with storage of RLO semantically is done first in order to prepare the learning templates that govern the manipulation of RLO

automatically by semantic web. This is followed by Metadata generation which is a part of RLO Searching. The third processes in proposed framework is the RLO classification used for RLO evaluation which is followed by the final process of RLO assembly. The order of execution therefore changes from Searching of RLO, Evaluation of RLO, Storage of RLO and Assembly of RLO used to represent challenges lectures face (as in figure 1) to Knowledge base creations, Metadata generation, RLO evaluation and RLO Assembly in the framework (as in figure 2).

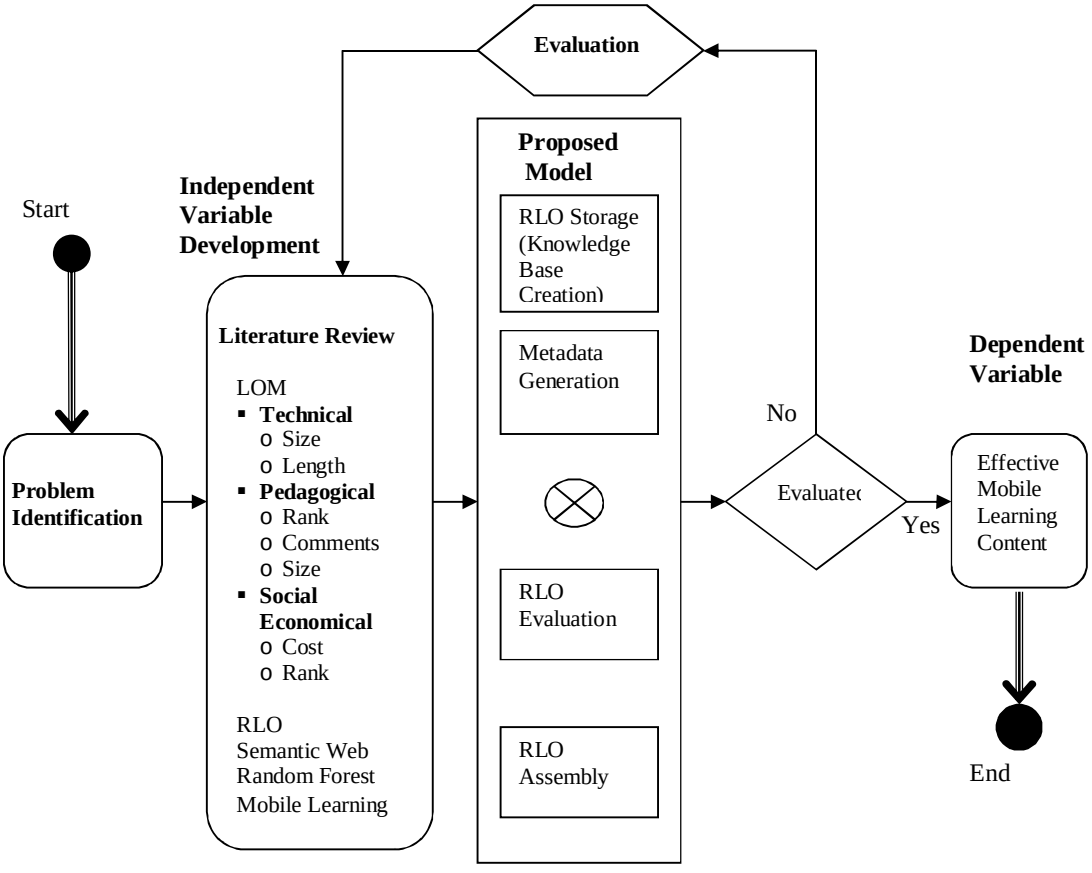

Figure 2: Conceptual Framework for Research Study on a Framework for Reusing Effective Learning Objects for Mobile Devices.

1.9 Thesis Organization

This thesis is organised as follows. The first chapter has given the background of the study of the concept of the RLO and defined the research objectives this research is based on. The second chapter will describe in detailed the related work done by various researchers to assemble RLO. Chapter three will look at the methodology of developing and evaluating the framework of assembling the RLO based on the semantic web and random forest. Chapter four will present the implementation of the framework in a prototype. Chapter five will present the evaluation of the framework including the experiment, the results and the discussion on the results.

1.10 Summary

This chapter has introduced the research study whose main purpose is to assemble effective mobile learning contents from online reusable learning objects. The chapter has discussed in details the problems associated with using the semantic web to assemble the RLO. The chapter has gone further to highlight the research questions derived from the problem statements that this research study ought to work and by doing so add up some contribution to the overall body of knowledge of semantic web and reusable learning objects in mobile learning. The overall research methodology has been described to show the research was carried to arrive to the proposed framework.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

The literature review sheds light in the problem area highlighted from previous section. The review starts by explaining what mobile learning is all about and follows up with the description of technologies involved in the proposed framework which include Semantic Web and Random Forest. In discussing Mobile learning, all the challenges for mobile devices to access the learning contents will be given together with the analysis of the learning contents that can be effective for mobile devices. In semantic web, ontologies, knowledge base, inference and reasoners will be discussed. The description of RLO and its attributes including the metadata and their repositories will also be given. The related work that has used these technologies to retrieve RLO from the search engines and assemble them into complete learning contents will be described afterwards in order to show the research gaps. Each related work based on the problem areas cited in figure 1 will be described separately including metadata generation, RLO evaluation, and RLO assembly.

2.2 Mobile Learning

Mobile devices act as providers of learning contents and supporters of learning activities to the students (Muyinda, 2010). In defining mobile learning, researchers have incorporated learning mobility but they have not made it a necessity since mobile devices can also be used for learning when the user is static or mobile. The key point should be learning that is not fixed, i.e. the learners can be in the classrooms, at their homes or on the move. This study will then adopt the broad definition by Mobile Learning Network (MOLENET) that mobile learning is the use

of ubiquitous handheld technologies, wireless and mobile phone networks, to facilitate, support, increase and expand the reach of teaching and learning (LSN, 2010). This is in line with the definition from University of Malaya that Mobile learning is learning that can take place at school or at home by the use of personal or shared devices which may be mobile or static (Dewitt and Siraj, 2011).

2.2.1 Mobile Learning Frameworks

The use of mobile devices has mostly been regarded as informal and used mostly as a support system to electronic learning. In 2002, the UK Learning and Skills Development Agency (LSDA) developed a mobile learning system to access learning contents and services aimed at helping young adults aged 16 to 24 in Europe (Kukulska-Hulme et al., 2011). In South Africa, Mobile learning (M-learning) has been used by University of South Africa (UNISA) to notify learners about different activities regarding their studies through Short Message Service (SMS) (Muyinda, 2010). The Open University of Malaysia (OUM) uses mobile device technologies to keep learners connected to the university, their peers, and their tutors (Lim et al., 2011, Peng et al., 2010). The studies above show that most institutions use mobile learning as a support mode. The institutions have not taken fully advantages to access the learning contents by mobile devices because of the lack of learning materials that can be utilized by mobile devices. There also have been frameworks to implement mobile learning developed by various researchers. However, most of these frameworks are not integrated to the institutional learning system and their impacts have not been well studied in practise. Table 1 summarises the frameworks that this study will be based on and establish the research gaps in the context of reusing learning objects.

Table 1: Mobile Learning Frameworks

Research Work	**Description**
M-learning content hoarding model (Trifonova and Ronchetti, 2006)	Take contents from the internet and transform them into mobile PDA format to be used online and offline mode
Adaptive m-learning Environment (Nakabayashi et al., 2007)	Provides an adaptive PC and Mobile self-learning Environment in online and offline learning using mobile phones
Semantic Web based M-learning Objects Repository (SWmLOR) (Pathmeswaran and Ahmed, 2011).	The RLO metadata in SWmLOR are under Dublin CORE metadata which implements a part of Institute of Electrical and Electronics Engineers (IEEL) LOM and the RLO are combined following Advanced Distributed Learning (ADL) SCORM.
An m-learning objects deployment and utilisation framework MoLODUF) (Muyinda et al., 2011).	integrating m-learning with conventional e-learning by deploying RLO as learning materials in Mobile phones using four mobility dimensions, namely: m-learning Cost, m-learning Processes, m-learning Objects and m-learning Context
Mobile Learning Framework for Lifelong Learning (Nordin et al., 2010)	How mobile learning applications can be designed based on four perspectives: generic mobile environment issues, learning contexts, learning experiences and learning objectives.

2.2.2 Limitations and Challenges of Mobile Devices in deploying Effective Learning Contents

The mobile devices were developed with the primary functionality of communication but have been adapted to other domains including education. Because they were not originally developed for education, the mobile devices contain many diverse limitations in terms of storage size, processing power, screen size, battery life, connectivity and cost when they are used in mobile learning. Past studies such as (Ryu and Parsons, 2008), (Richey et al., 2010) and Mai (Mai, 2015) have grouped the challenges of mobile learning to span between Technology, Pedagogical and some aspects of Social. Also the research study by Khaddage et al discusses the challenges of mobile learning as pedagogical, technical, policy and research based (Khaddage et al., 2015). The other study by Khan et al also highlights the context as the social challenge in adopting mobile learning (Khan et al., 2015). Furthermore because of the nature of mobile devices introducing the issues of cost of purchasing and running the devices then the economic challenges have to be considered also. In view of the above facts, this research study addresses the challenges in three dimensions of Technology, Pedagogy and Social – economical.

Technologically the mobile device cannot save and transmit large amount of learning resources. The mobile devices have limited processing power, limited display size as well as low transmission, storage and power (Uden, 2007). In addition to that, it requires the learning contents to be small and use less processing power. On top of that the display area of the mobile device can accommodate little information at ago which renders the mobile device very ineffective in deploying the learning contents (Park et al., 2011).

Pedagogically it may be hard to deploy effective learning contents in mobile devices. There are lot of things to consider as will be detailed later on in section 2.2.3 including learning theories, learning styles and learner preferences (Richey et al., 2010). M-learning field is still young and therefore pedagogical factors have yet to be fully merged into mobile devices. It will then pose a huge challenge for the institutions to develop effective learning contents with all the pedagogical features in the mobile devices.

The use of mobile devices has social economic implications in the community. Socially the culture of people to use mobile devices is not a common thing and economically it is still expensive to use mobile devices for learning. Many people including the teachers perceive mobile devices as social gadgets and do not put much trust in contents available through mobile devices (Mai, 2015). On the other hand it is expensive to pay for the mobile operational costs when accessing the RLO using mobile. Not only that but also learners are bound to spend a lot of cash to buy powerful mobile devices to be able to participate in the m-learning activities (Ekanayake et al., 2015). These factors pose a big challenge to institution that want to take up on mobile learning.

2.2.3 Effective Learning Contents for Mobile Devices

Given the limitations of mobile devices described in section 2.2.2 it can be see how hard it is to obtain effective learning contents for mobile devices. Effectiveness of learning contents is viewed differently by groups. The United States National Research Council produced a synthesis of research into educational effectiveness across ages and subject areas and concluded that effective learning is learner

centred, knowledge centred, assessment centred, and community centred (Sharples et al., 2005, Bransford et al., 2000).

The study by Hyu and Ching gives a review of models and frameworks for mobile devises and classify them in technological acceptance, pedagogies, evaluation and psychological construct (Hsu and Ching, 2015). Also Content, Pedagogy and Knowledge (PAK) model initially introduced by Shuman is renown to represent effective education and extended by technology in education model Technological Pedagogical Content Knowledge (TPACK) by other researchers to integrate technology in education (Rosenberg and Koehler, 2015).

Ryu and Parson described that effective learning can be achieved in three learning space: Individual, Collaborative and Situated (Ryu and Parsons, 2008). In order to be successful a learner has to use not only one learning space but a combination of all the learning space. Individual learning space involves the learners working on their own while using a set of materials and instructions prepared by the instructors (Tony et al., 2004). In Collaborative learning the learner attains new knowledge by engaging in a discussion and interaction with his friends and fellow students (Amel et al., 2006, Dewitt and Siraj, 2011). And lastly in situated learning the learner uses the environment and things surrounding him to construct new knowledge by relating what is happening in the environment with the learning contents and instruction provided to him (Amel et al., 2006).

Table 2: Theories used in Mobile Learning

No	Learning Theory	Description
1.	Social Constructivist Theory	Social Constructivist theory combines both the social learning theory and constructivism theory (Brown, 2005). Social Constructivism posit that knowledge is a social product because knowledge creation is shared through interaction of a number of minds and rather than an individual experience (Muyinda, 2010).
2.	Informal Learning Theory	Informal learning can occur by accident without knowing (such as getting information on a class material through a message from a friend in social network site) or intentional when we use the informal means to complement our learning activities (such as accessing the profile of lecturer in order to find to find the class materials) curriculum (Muyinda, 2010).
3.	Learning and Teaching Support Theory	Learning is not all about contents but rather it also includes coordination between learners and the resources (Muyinda, 2010).
4.	Usability Theory	The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Petersen, 2007).

5.	Interactivity Theory	These are learner to learner interaction, learner to content interaction and learner to lecturer interactions. Learner to content interaction will cover the personalized (individual) learning space while learner to learner and learner to lecturer interaction will cover situated and collaborative learning

The effective learning contents have to be guided by learning theories. There exist different theories that have been used to guide mobile learning (Sharples et al., 2005). As there is no unified learning theory that can be used to guide the development of the effective learning contents then the study will have to merge both the theories that have worked well in learning community, and the general use of ICT devices in learning**.** The learning theories guiding the learning contents for mobile devices are summarized in the table 2. The most common aspect of the learning theories is the use of interactivity, collaboration and personalization.

Figure 3 summarises the three areas that have been mentioned as the constituents of the effective learning materials earlier in this section. The learning materials have to be able to be used in all the areas in order to be effective. Technologically the learning contents have to be able to adapt to devices and applications of the users while pedagogically the learning contents have to match the learning theories (Learning space and learner centred) and characteristics of effective education specifically. In addition to that the contents must fulfil social economical aspects such as being affordable and appropriate to the learning context.