Exploring mobile learning opportunities and challenges in Nepal: the potential of open-source platforms

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Abstract

With the increasing access to mobile devices in developing countries, the number of pilots and projects embracing mobile devices as learning tools is also growing. The important role it can play in improving education is also positively received within education communities. But, providing a successful mobile learning service is still significantly challenging. The considerable problems arise due to existing pedagogical, technological, political, social and cultural challenges and there has been a shortage of research concerning how to deploy and sustain this technology in a resource constrained educational environment.

There are studies mainly conducted in sub-Saharan countries, India, and Latin America, which provide some guidelines for incorporating technology in the existing educational process. However, considering the contextual differences between these regions and other countries in Asia, such as Nepal, it requires a broader study in its own challenging socio-cultural context.

In response to this difficulty, the aims of this exploratory research work are to study the distinct challenges of schools' education in Nepal and evaluate the use of open-source devices to provide offline access to learning materials in order to recommend a sustainable mobile learning model.

The developmental study was conducted in University of West London in order to assess the feasibility of these devices. The main study in Nepal explored i) the overall challenges to education in the challenging learning environment of schools with limited or no access to ICT, ii) how ICT might be helping teaching and learning in the rural public schools, and iii) how an offline mobile learning solution based on the open source platforms may facilitate English language teaching and learning. Data collection primarily involved interviews, questionnaires, observations and supplemented by other methods.

This thesis presents the sustainable model for deploying and supporting mobile technology for education, which is based on the findings emerging from completed exploratory studies in Nepal. It highlights all the aspects that need to be addressed to ensure sustainability. However, to translate this understanding to a design is a complex challenge. For a mobile learning solution to be used in such challenging learning contexts, the need is to develop simple and innovative solutions that provide access to relevant digital learning resources and train teachers to embed technology in education. This thesis discusses these findings, limitations and presents implications for the design of future mobile learning in the context of Nepal.

"Man built most nobly when limitations were at their greatest."

~ Frank Lloyd Wright

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For Raphi,

Thank you, for everything.

And to my dearest daughter Shreya,

For your smile that gave me the strength.

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Dedication

This thesis is dedicated to the memory of those who lost their lives in the April 2015 earthquake in Nepal.

Contents

List of Abbreviations

ICT	Information Communication Technology
ICTD or ICT4D	Information Communication Technology for Development
ICT4ED	Information Communication Technology for Development and Education
ML4D	Mobile Learning for Development
BoP	Bottom of the Pyramid
HCI	Human Computer Interaction
M-HCI/D	Mobile Human Computer Interaction and Mobile Design Research
EFA	Education For All
PC	Personal Computer
XO (OLPC)	One Laptop Per Child
OSS	Open Source Software
OSH	Open Source Hardware
GNU	GNU's Not Unix
OS	Operating System
ISP	Internet Service Provider
CLT	Communicative Language Teaching
ELT	English Language Teaching
CDC	Curriculum Development Centre
OLE	Open Learning Exchange
NWNP	Nepal Wireless Networking Project
NEA	Nepal Electrical Authority
MOE	Ministry of Education

GON	Government of Nepal
SLC	School Leaving Certificate
HSEB	Higher Secondary Education Board
INSTIL	Institute for Teaching, Innovation and Learning
UWL	University of West London
UNESCO	The United Nations Organization for Education, Science and Culture
UNDP	United Nations Development Programme
DFID	The Department for International Development
UNICEF	The United Nations Children's Emergency Fund
GSMA	(Groupe Spéciale Mobile) Association
ADB	Asian Development Bank
GDP	Gross Domestic Product
NGO	Non-Governmental Organisation
USB	Universal Serial Bus
TFT	Thin-Film-Transistor
LCD	Liquid-Crystal Display
DNS	Domain Name System
UK	United Kingdom

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Glossary

Public Schools: In the existing Education Act and the relevant Regulations, the school owned, managed, financed and regulated by government has been recognized as public or government schools, *'sarkari school'* in Nepali.

Private Schools: The privately financed, managed and regulated by parents' association, business, non-profit organisation or a religious institution is called the 'institutional school' or private school.

Community Schools: The schools that are either funded by the government or do not receive a regular government grants and financed with support from community, donations from other sources and school's own resource, and managed by some non-government body, such as a community are called community schools, *'samudayik school'* in Nepali.

ICT4D: Information and communication technologies for development (abbreviated as ICTD or ICT4D) helps to broaden the understanding of the associated challenges in the process of implementing a technological intervention in the context of developing regions. It involves multiple sectors and draws interest from multiple disciplines.

ML4D: It highlights the need for specific guidelines to assist mobile learning deployment in developing countries such as Nepal.

Copyleft: According to GNU, ccopyleft is a general method for making a program (or other work) free, and requiring all modified and extended versions of the program to be free as well.

Offline: systems are based on the learning material uploaded in the users' mobile device and can be accessed without the need of wireless communication.

Open-Source: refers to something people can modify and share because its design is publicly accessible. Open source software is software with source code that anyone can inspect, modify, and enhance. Open source hardware is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design.

Chapter 1

Introduction

This chapter introduces the context of this research, elaborates the background of this study and draws the *research question* and sets the objectives to address in this thesis that is to identify overall challenges to deploy a sustainable mobile learning solution to support teaching and learning in Nepal.

1.1 Research context: Nepal

Figure 1: Map of Nepal

A mountainous country Nepal, officially the Federal Democratic Republic of Nepal, is one of the least developed countries in the world[1]. Located in south Asia, it is a small landlocked developing country between India and China (see Figure 1) where most of the countryside is remote and constrained by limited natural resources and poor infrastructure. While the country is still recovering from a ten-year civil war (1996 – 2006), it will take

[1] UNDP List of Least Developed Countries (as of May 2016) http://www.un.org/en/development/desa/policy/cdp/ldc/ldc_list.pdf

many years to overcome the damage from the devastating earthquake of April 2015.

Though the first constitution was promulgated in 20th September 2015 after eight years of deliberation by the democratically elected representatives of citizens of Nepal, the country is facing extreme political instability as the mainstream political parties are unable to deal with demand from ethnic minorities.

Nepal is a multi-ethnic, multilingual, multi-religious and multicultural country with an estimated population of 28.17 million[2] and the last census in 2011 showed there are 123 languages being spoken and 125 Caste and ethnic group residing in a Nepalese society (Pangeni, 2016, p.35).

Nepal has a high rate of poverty and according to the United Nations Development Program, poverty in Nepal has increased over the past three decades, especially in rural areas (UNDP, 2010). Over 30 per cent of Nepalese people live on less than US$14 per person, per month, according to the national living standards survey conducted in 2010/11 by the Central Bureau of Statistics. While the overall poverty rate for Nepal is 25 per cent, this figure increases to 45 per cent in the Mid-Western region and 46 per cent in the Far-Western region.

A large proportion of the rural population of Nepal is illiterate. According to the Government of Nepal's the recent Statistical Pocket Book[3] 2014, the literacy rate of male and female are 75.1 and 57.4 per cent giving on average of 65.9 per cent. According to school sector reform plan report

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[2]GSMA Mobile Connectivity Index http://www.mobileconnectivityindex.com/
[3] Government of Nepal, Central Bureau of Statistics http://cbs.gov.np/publications

(2009-2015), approximately half of the population in Nepal lacks the basic skills of functional literacy and numeracy (MOE, 2009, p.1). “Gender disparity in adult literacy rates is an even more critical problem in some Asian countries, such as India, Nepal and Pakistan, where the female literacy rate is considerably lower than the male literacy rate” (So, 2012, p.12).

“Many schools in Nepal still have no electricity as only 6% of primary schools and 24% of secondary schools have electricity” (UNESCO, 2015, p.571). Kumar *et al.* (2015, p. X) states that:

“In spite of the techno-economic potential to generate 43,000 MW of hydroelectric power, Nepal is currently facing a crippling energy crisis. In the fiscal year of 2013-14, Nepal’s domestic generation met only 60% of the energy demand of grid-connected consumers. Import from India comprised 18% of the total energy supplied. Nearly, 22% of the demand could not be supplied, leading to load shedding in the grid for up to 12 hours per day. Moreover, around 33% of the country’s population, mostly in rural and remote areas, does not have any access to grid or off-grid electricity.”

In a bid to cope with the power crisis that has plagued the country, The Nepal Electricity Authority (NEA) regularly announces daily load-shedding schedule. As reported in the media, according to NEA, Nepal will continue to reel under power cuts for six to seven more years and in the dry season, the duration of load-shedding is up to 14 hours a day.

Nepal's topography makes it extremely difficult to develop the much needed telecommunications infrastructure. Regardless of the increasing mobile penetration, the Internet segment of the market remains sluggish.

However, the recent draft of National Information and Communication Technology Policy 2015 aims to achieve entire population of Nepal to have access to internet by 2020 which seems a rather optimistic goal. World Bank estimates only 15.4 people out of 100 had an access to internet in 2014 and according to Nepal telecommunication authority, only 20% of the total population of the country have access to Internet and is mostly limited to urban areas of Nepal where 80% of population live in the rural areas. 50% of Internet access points are inside the capital – Kathmandu Valley and overall 90% of available points are located in urban areas.

While availability of ICT infrastructure remains a crucial to integrate ICT into the curriculum, mobile phones have perhaps the greatest potential for delivering ICT-based learning to the marginalised, and even in fragile contexts as it requires less infrastructure than computers (UNESCO, 2015). Therefore, a cost-effective mobile learning solution can enhance a classroom learning experience and extend it beyond.

This research study will focus on investigating the possibility of using mobile platforms to provide learning resources to support teaching and learning English subject, which is a part of Nepal’s public school's curriculum. It will include research sites in five districts of Nepal: Chitwan, Makawanpur, Lalitpur, Mustang and Kapilvastu of Nepal. The sub-study 1 and 3 will be conducted in Chitwan and the sub-study 2 will involve 8 under-resourced rural public schools from 4 other districts mentioned above.

1.2 Background of the study

For many years, forecasts have shown the rapid increase in adoption of mobile phones and the penetration is expected to soar in the coming years. Decreasing cost of an ICT with improving functionalities and access to services has led to wider availability and adoption of the portable mobile devices around the world. The developing countries are home to more than three quarters of all mobile-cellular subscriptions. According to the ITU report, by end 2015, there are more than 7 billion mobile cellular subscriptions, corresponding to a penetration rate of 97%, up from 738 million in 2000 and global Internet penetration also grew 7 fold from 6.5% to 43%. Globally, mobile broadband penetration has also reaches 47% in 2015, a value that increased 12 times since 2007 and the global penetration of internet-enabled smartphones is also expected to grow.

This rapid mobile communication technology development has given opportunities for economic and social development even in developing countries. Many ICT4D projects leverage the widespread availability of mobile phones as the ultimate intervention to achieve their development goals (Molapo and Densmore, 2015). Mobile capabilities are increasingly explored to realise productivity and efficiency in variety of contexts such as to improve health, governance, agriculture and business by meeting day-to-day communication and information needs.

Therefore, “the integration of ever growing number of mobile devices, application and services into people’s daily lives on a personal and professional level is continuously increasing” (Hagen *et al.*, 2005a, p.1). But, according to Dearden and Tucker (2015, p.1):

"ICT4D is a difficult challenge for Engineering, since the nominal outcome (Development) is a social, rather than a technical phenomenon, and it lacks a universally accepted definition. Given the difficulty of designing interventions in complex social situations, it is important for engineers and researchers to develop an understanding of the contexts where they are working".

Thus, bridging the digital divide particularly in education remains a challenge as only providing access to computers and internet services does not reduce the digital gap in education (Thapa and Sein, 2016).

However, as the concept and idea of using mobile devices for education is also growing, the investment in the exploration of mobile technology is also in rise and expected to deliver the learning outcomes. Even though mobile learning is a relatively new, it is rapidly gaining momentum looking for teaching and learning opportunities even in the remotest areas of developing countries. There are increasing attempts to explore or expand the use of ICT in Education in developing countries and there are number of studies that focused on mobile learning in the context of developing regions like Africa, China and India which evaluated mobile learning in controlled classroom and unsupervised settings as well (Kumar *et al.*, 2010).

Even though serious education challenges cannot be solved by simply introducing computer and internet technologies in low-income schools (Warschauer *et al.*, 2004), there are evidences of the use of ICT in education within developing countries that demonstrated its potential to have a positive impact when an appropriate technology was combined with quality curriculum-based content (Sahni *et al.*, 2008; Hollow and Masperi, 2009; Hutchful *et al.*, 2010; Thapa and Sæbø, 2011; Bass and Thapa, 2014).

The exploration of the use of mobile technology to support language learning around the world is also increasing which shows that the ICT intervention in language teaching and learning is facilitating transition from teacher-centred approaches towards more student-centred ones, such as Communicative Language Teaching (Vihavainen *et al.*, 2010) which emphasizes on interaction. Previously, one of the applied research project in Sub-Saharan Africa showed the improvement to access and quality of an education by the use of mobile technologies (Leach *et al.*, 2006). One of the key policy implications raised by this study was the need to further investigate in a wider range of contexts and purposes of the potential of new mobile technologies.

Due to difficulty of adapting technology to the users need and vice versa (Deegan and Rothwell, 2010), the bigger challenges are of embedding mobile learning applications, sustaining and scaling for future remains (Traxler, 2011b). In the UNESCO Working Paper Series on Mobile learning, as Carly *et al.*, (2013; p.7) highlighted:

"Despite over fifteen years of research, mobile learning has so far failed to have a significant long-term impact on education. Designing effective mobile learning interventions requires a holistic understanding of how technology intersects with social, cultural and, increasingly, commercial factors. Over the next fifteen years, the implementation of mobile learning projects and the pedagogical models they adopt should be guided not only by the advantages and limitations of mobile technologies but also by an awareness of how these technologies fit into the broader social and cultural fabric of communities."

Therefore, it is crucial for technology research to identify the best-fit solutions for developing regions (Brewer *et al.*, 2005) that integrates with the social and cultural practices of the locality to make sure it is a sustainable solution and for long-term use and benefits (Evans *et al.*, 2008).

UNESCO (2015, p.213) refers to a work by (Lugo and Schurmann, 2012) and (Isaacs, 2012) that demonstrated mobile learning initiatives have the potential to become a resource for teachers and students in Latin America and the Caribbean and in the Arab States and sub-Saharan Africa. A detailed discussion of wide range of technical, environmental, and cultural challenges in general (mainly in the context of India, Ghana and Cambodia) provided some guidelines for implementing different ICT related solutions in developing regions (Brewer et al., 2006). Schwartz et al. (2014) offered guidelines for mobile deployment which could be useful for governments, NGOs, and funding agencies who arm frontline workers with mobile devices as tools to improve service delivery, monitoring, and evaluation. According to Thapa and Sæbø (2014, p.10), "more research is also certainly needed to consider the contextual differences between the different regions such as, for instance, the developing Arabic countries, and other countries in Asia, such as Nepal". In a culturally rich Nepalese society, need a multi-cultural education system and different modes of learning fitting to the existing cultural practices (Pangeni, 2016).

Supporting teaching and learning in Nepal and improving education is not a straightforward process, understanding of which may help to explain the failure and successes of future projects. In remote public schools of Nepal, poor pedagogical approaches, untrained teachers, scarcity of text books and students dropout are some of the major challenges in education (Thapa and Sein, 2016). However, as Shields (2011, p.86) highlighted, even though the cash-strapped and over-burdened education system of Nepal struggles to provide basic education, it presents an ideal test case to evaluate the arguments for ICT in education. In the Information & Communication Technology in Education Master Plan 2013 - 2017, use of ICT in education has also been considered as one of the strategies to achieve the broader goals of education.

Thus, to design and implement a sustainable mobile learning solution in developing countries requires guidelines on how to introduce mobile technology to support teaching and learning. Therefore, there is a need to identify the unique set of challenges in existing teaching and learning practices in the current social, cultural and political context and to yield a deeper understanding, this study focuses on how a mobile learning may work from developing countries perspective.

1.3 Statement of the problem

Mobile phones can play an important role to support teaching and learning and mobile learning approach to education sounds appealing in the context of developing countries. There are increasing attempts to explore or expand the use of ICT in Education and there are growing number of studies that focused on mobile learning in the context of developed and developing regions as well. However, regardless of increasing projects and pilots globally and encouraging and positive evidences, mobile learning is still an emerging and maturing field and to identify the best mobile technology to use at the beginning of any ICT4D project is still a challenge. In Nepal, there is a clear knowledge gap that highlights various challenges faced while exploring the use of mobile devices in schools which has direct implications on sustainability of such ICT interventions.

"Smartphones are trending upwards due to declining prices, higher computing offerings, improved interactions and future potential in developing regions but require additional considerations because of poorer battery lives, higher costs of use and the issue of liability and security" (Molapo and Densmore, 2015, p.4). Due to lack of access to electricity, charging smartphones regularly is challenging and the total cost of devices and their associated services is still one of the major concerns and one of the most significant barriers to using technology, especially in the low-income developing countries.

With the rapid advancement and proliferation of both 'open-source' and 'closed' mobile technologies, today mobile learning researchers are examining mobile features and functionalities to develop a best fit-for-purpose solution. Open-source platforms could support creativity, provide freedom and unlimited choices for developers and end-users and allow development of cost-effective hardware and software solutions. It can also have considerable economic and social impacts on the further design and development of technology and its uses in various contexts. But its potential and associated risks remain unexplored for supporting education.

Due to advancing and changing nature of mobile technology, the focus of many mobile learning initiatives have often been on evaluating the technical capabilities of a specific mobile technology by deploying in academic settings to identify the pedagogic possibilities (Traxler, 2011b). Hence, there are many examples of mobile learning studies that experiment the feature rich sophisticated devices in educational settings, confidently making claim of increasing engagement and frequency of access and achieving better results.

The mobile learning literature clearly points out that the focus on the technology aspect has been more than necessary and the challenges remains associated with how the technology is adopted and used for mobile learning. Most of the mobile learning research and development has been proof-of-concept, project-based, fixed-term and small-scale and lacked consolidated view of how to sustain the practices or opportunities that are being explored (Traxler, 2011a; Parsons, 2014; Ng and Nicholas, 2013). In the recent study of Open Learning Exchange (OLE) project in Nepal which has implemented education projects based on OLPC computers highlighted the need to move away from techno-centric approach and take a holistic approach to successfully address some of the challenges of providing quality education (Thapa and Sein, 2016) .

In Nepal, the penetration of affordable mobile phones is relatively higher than desktop computers mostly due to poor or non-existing landline infrastructure and education can take an advantage of this growth. But mobile learning is still a new concept as “it is not just a mere provision of devices in resource-poor settings, in particular when it is not clear what pedagogical innovation or value the device features" (Langer et al., 2014).

In Nepal, the lack of relevant education materials, poor pedagogical approaches and untrained teachers are still the major challenges in majority of schools. However, Nepal's current ICT in Education Master Plan 2013 – 2017 considers the use of ICT in education as one of the strategies to achieve the broader goals of education. But, to support teaching and learning in Nepal's own socio-cultural context is a significant challenge and remains under-researched.

Traditionally, Nepalese teachers and students had no choices more than chalk and talk including blackboard and textbook as teaching materials (Pangeni, 2016). "Despite the hype and fevered activity, very little research has explored the real and potential impact of online education in the developing world" (Cutrell *et al.*, 2015, p.1). To recognize and implement the benefits of open and distributed learning in Bhutan and Nepal, Rennie and Mason (2007) found the technical and socio-cultural challenges of a much greater order of magnitude. While limited or inconsistent internet access does not allow any reliance on net-based learning solutions, the academic culture resistant to the recognition of the value of open-learning degrees hinder re-designing course materials for a more educationally flexible, student-centered learning environment.

Thus, there is a need to understand the existing teaching and learning practices, and design solution based on the distinct understandings of a local context, to fully incorporate technology in the existing educational process. Therefore, the major challenge remains associated with how the technology is adopted for a specific user group and used for mobile learning. By identifying and addressing these aspects in any educational context increases the chances of sustaining and possibly scale the mobile learning solution in the future.

Current research in the ICT4D lack common understanding of concepts, challenges, and opportunities in the developing countries as they are mainly based on Sub-Saharan countries, India, and Latin America (Thapa and Sæbø, 2014). In the context of Nepal, there is a lack of understanding of the overall challenges that hinder the mobile learning deployment to support traditional teaching and learning practices. Thus, the need is to identify sustainability factors to assist the design of a mobile learning solution based on a flexible technology platform with the clear understanding of teachers' and students' educational requirements and the overall learning context.

1.4 Research questions

The research question that this research specifically aims to address is:

"What are the challenges of introducing ICT for supporting schools' education in Nepal and how might we design a sustainable mobile learning solution using open-source platforms?"

The research question for this research takes account of the need to understand the existing teaching and learning practices and design solution based on the distinct understandings of a local context to fully incorporate technology in the existing educational process. It takes the bottom-up approach to understand the user need and context before investigating the potential of technology to address that need by exploring its use. The primary research **aim** is centred on identifying sustainability factors to design a mobile learning solution. In order to answer the major question, below are the subset of research questions which aim to address the problems in detail. All these questions are distributed across a developmental and three sub-studies according to the different stages of the research. Outcome based on the findings emerges from the evaluation of users, their needs and their context from these studies.

1.4.1 What are the benefits and difficulties of using open-source mobile devices for teaching and learning? (UK Developmental Study) Conduct a study to understand and evaluate the usefulness of the open-source devices to provide an access to the necessary resources and support learning.

1.4.2 What are the challenges of teaching and learning in schools of Nepal? (Sub-study 1 and 2) Conduct exploratory studies to understand these challenges in the schools with or without an access to ICT.

1.4.3 What are the benefits and difficulties of using open-source mobile devices to support teaching and learning in the context of Nepal? (Sub-study 3) Conduct a study to evaluate the use of open-source mobile devices and determine whether there are any aspects of teaching and learning English language that it can support.

1.5 Outline of the dissertation

This thesis is divided into seven chapters. The **first chapter** introduces the subject, further elaborates the background of this research in the context of a developing country - Nepal, draws the research question and sets the objectives to address in this thesis.

Chapter 2: This chapter describes the theoretical background of this thesis, focusing on the main concepts of mobile learning that have informed this research. It further discusses the development of the Open-source platforms, specifically Nanonote and Wikireader devices. This chapter will discuss the mobile technology used in educational context and highlight the possible role open-source devices can play.

Chapter 3: This chapter describes the overall research approach, the procedures and methods used to collect and analyse the data to evaluate the open source platforms emerging from the evaluation of users, their needs, context and technology.

Chapter 4: This chapter reports on a developmental study of students' exploration and use of Nanonote and Wikireader mobile devices for offline mobile learning in UK. They used devices for learning embedded programming in the context of UK higher education.

Chapter 5: This chapter describes exploratory studies carried out in public and private schools (generally believed to be better than public schools) using traditional teaching practices and with or without an access to ICT. The study was carried out to identify the challenges of education in the context of Nepal with the focus on teaching and learning English language.

It also includes qualitative study conducted in public schools from 4 different districts that use XO laptops and supported by Open Learning Exchange Nepal. The study identified the benefits and challenges of using ICT in poor schools and investigated how the use of ICT may be helping to solve some of the concerns identified from the earlier study.

Chapter 6: This chapter reports on a study that explored the use of open-source devices in the formalised traditional teaching setting of schools in Nepal. The devices were used to support teaching English within a well-defined curriculum of class 9 and 10 by providing an offline access to relevant learning resources. It further highlights the challenges to develop a sustainable mobile learning solution.

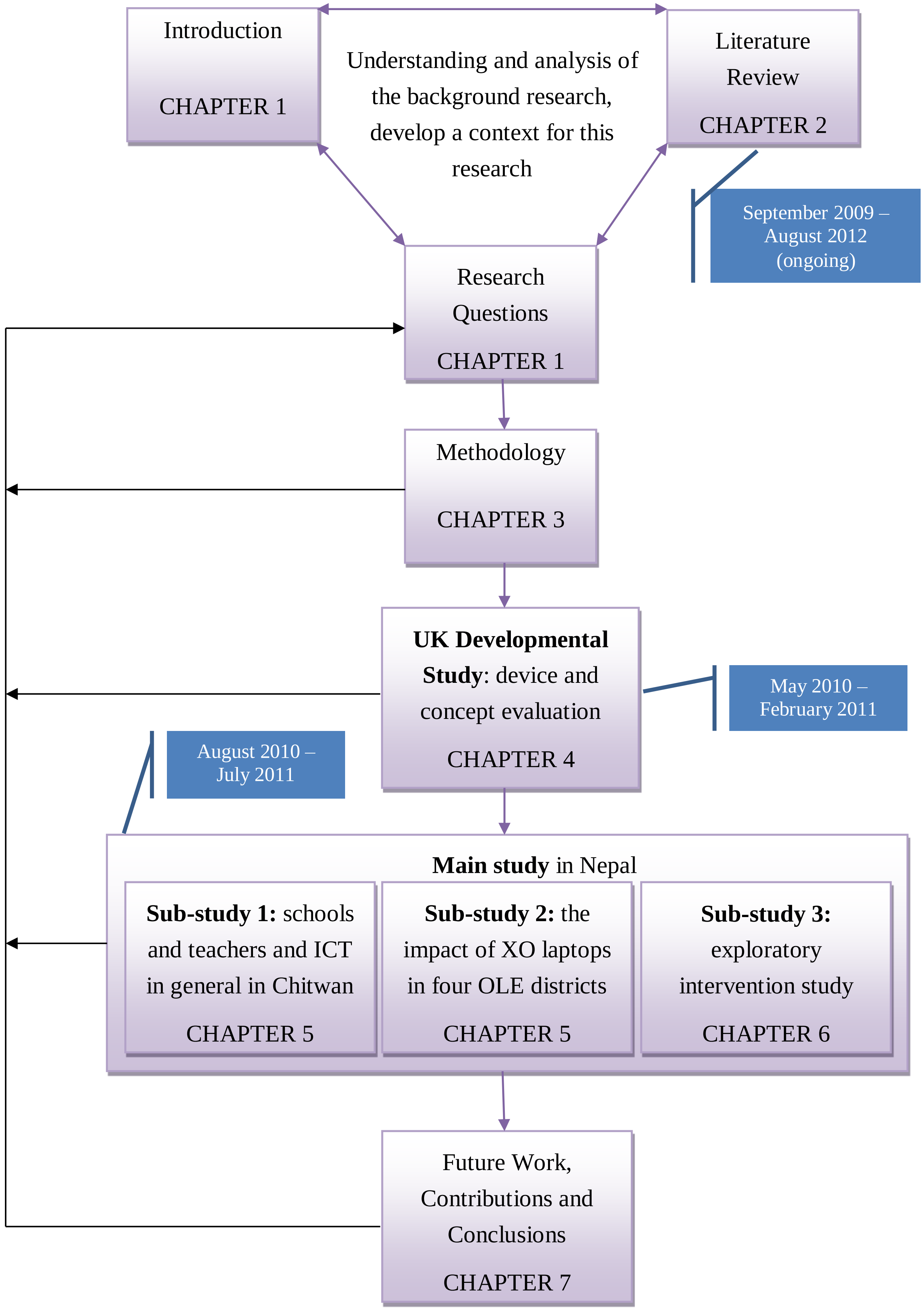
Chapter 7: This chapter will highlight the key findings of the research reviewing the outcomes of the studies presented in the above chapters. It reflects on how the research contributes to an understanding of the contexts that could facilitate the introduction of the mobile devices as a learning tool in schools of Nepal.

Chapter 8: This chapter concludes highlighting the contributions to the field of study, limitations of the research, future work and directions.

Thesis contributions:

- a novel use of open-source platforms
- detail discussion on the choice of theory and methods used
- identify major challenges to design a sustainable mobile learning solution in the context of a developing country – Nepal
- offline mobile learning: why and how?
- limitations/weakness of this research and further recommendations to conduct such a study. (**Note:** For a detailed discussion of thesis contributions, please refer to **Chapter 7.4**).

1.6 An overview of the research



1.7 Timeline / Work plan

The first year of this research study beginning September 2009, I spent familiarising with the research area, reading papers and identifying problem areas. At the end of first year, I identified quite closely the area I wanted to work in and develop some ideas on which thesis could be based. Literature review was an ongoing process. In February 2010, I also completed Post Graduate Certificate in Research which was a requirement for doing this PhD. At the very beginning of this research study, following studies were planned:

- An exploratory study A (understanding the challenges of teaching and learning English in public schools of Nepal).
- An exploratory study B (a study to understand the existing teaching and learning practices in private schools of Nepal).
- An exploratory study C (in the schools supported by OLE Nepal to investigate how the use of ICT in teaching and learning is helping to solve some of the concerns identified from the above exploratory studies).
- An exploratory study D (identifying the type of resources and technological needs for schools in Nepal).
- Pilot study A (evaluation of open-platforms for delivering offline mobile learning).
- Pilot study B (to explore the use of low-cost open-source devices to deliver customised contents to support English language teaching & learning in public schools of Nepal).

In year two, I planned to carry out the bulk of research work - conducting developmental, exploratory and evaluative studies and establishing primary results. But, I somehow under-estimated difficulties/complexities of this research study considerably challenging and time-consuming. Work plan was further reviewed at the end of this year.

Considering the objectives of the study, timescale and resources available, there were some changes to the purposed studies. Exploratory studies A and B including an aspect of a study D were conducted as a sub-study 1. An exploratory study C became a sub-study 2 and a pilot study B was carried out as a sub-study 3. The purposed pilot study A in UK became a developmental study. Actual studies carried out:

- UK developmental study
- Sub-study 1: schools and teachers and ICT in general in Chitwan
- Sub-study 2: the impact of XO laptops in four OLE districts
- Sub-study 3: the innovation of low cost devices in schools of Chitwan

User performance / Data analysis started in August 20011 and I was able to begin writing up in November 2011. Due to the nature of the studies, analysis took more time than expected. Only at the end of the third year, I was able to draft the substantial parts of the thesis. Writing up and thesis submission also got further delayed due to my family and work commitments. However, during 2013 – 2015/ 2016 period I kept reviewing the literature. The recent literature reinforces the choice of Nepal as an ideal test case to evaluate the arguments for ICT in education (references UNESCO Education for all global monitoring report 2015 and Ministry of Education Nepal's latest study on implementation of English listening and speaking skills 2013 and other ICT4D/mobile learning related recent publications). The research purpose and rationale of this investigation is in line with the recent literature. Hence, the research question is still relevant and the purpose of this research study is justified.

UK developmental study was conducted to understand and evaluate the usefulness of the open-source devices to provide an access to the necessary resources and to support learning. The data collection for the UK developmental study started in May 2010 and was completed in February 2011. Chapter four reports on this study of students' exploration and use of low-cost open-source mobile devices Nanonote and Wikireader for learning.

Sub-study 1: schools and teachers and ICT in general in Chitwan was carried out between August 2010 and April 2011. This study examined the challenges that public and private schools face and highlight why the school education system is not effective in Nepal. The data collection for the field study in Nepal started while the UK developmental study was undergoing. Chapter five (section 5.1) reports this preliminary qualitative study.

Sub-study 2: the impact of XO laptops in four OLE districts was carried out between May and July 2011. The aim of this study was to examine the benefits and challenges of using ICT in schools and understand how the use of ICT may be helping to solve some of the concerns discussed as above in this chapter. Chapter five (section 5.2) reports this study.

Sub-study 3: *the innovation of low cost devices in schools of Chitwan* was also carried out between May and July 2011 for three months. It explored how an offline mobile learning solution based on the Nanonote and Wikireader devices may facilitate English language teaching and learning in the challenging learning environment of schools of Nepal. Chapter six report this exploratory study.

1.8 Conference papers and publications

Part of this submission has been reported in a number of research papers, all of which are listed in the contents pages. Conference paper 1 ("Offline Mobile Learning for ICT4D", Appendix O) and Journal Paper 2 ("Mobile learning and low-cost hardware for ICT4D: what's right and what's copyleft?", Appendix M) highlight the possible role of previously unexplored open platforms for delivering affordable and sustainable offline mobile learning in the context of ICT4D which is mainly based on Chapters 1 and 2. Conference Papers 2 ("Sustainable Mobile Learning: Open & Offline", Appendix P) and 3 ("Flexible learning with flexible devices: opening up opportunities", Appendix Q) presents the preliminary results from the UK developmental study. Journal Paper 1 ("Evaluation of a hands-on approach to learning mobile and embedded programming”, Appendix M) presents findings from this study reported in Chapter 4. Conference Paper 4 ("The English Language Teaching and Learning Challenges in Public Schools of Nepal: Teacher's Diary Study", Appendix R) is based on Chapter 5 and it presents the sub-study 1 which is an exploratory study carried out to identify the challenges of teaching and learning English in the government schools that use traditional teaching practices in Nepal. Based on the chapters 1, 2 and 3, Conference Paper 5 ("Open-source Platform: Exploring the Opportunities for Offline Mobile Learning", Appendix S) explains the research problem, the planned study in Nepal and the expected contribution. Further publications are planned to present the results from the main study.

Chapter 2

Literature review

The purpose of this chapter is to describe the theoretical background of this research. This chapter reviews the current literature relevant to the use of mobile technologies to support teaching and learning to gain a better understanding of the mobile learning concepts and highlights the challenges that it faces. This chapter reviews the use of mobile devices in developing countries and current state of mobile learning in general that lack thoughtful attention to the issues of affordability, device ownership, sustainability and scalability and also highlights the issues related intellectual property (IP) rights as one of the important technical challenges to develop a sustainable solution. With the thorough analysis of the educational technologies, the main purpose of this chapter is to describe the development of the open devices, highlight its possible role in mobile learning, and present some conclusions based on the findings and limitations of these initiatives and implications for this research. Furthermore, this chapter describes the technology that links the research studies in this research: Nanonote and Wikireader.

2.1 Literature review approach

This chapter is based on a systematic review of literature relevant to the use of mobile devices in education. The aim was to read and analyse literature relevant to this study, formulate the research questions and establish the direct link between those two (see Figure 2). In order to ensure that the review process is rigorous and valid, the relevant papers published in the leading journals relating to education and technology and their citations also reviewed. It also involved a review of mobile learning and ICT4D with the main focus on existing works in research and practice in the context of developing countries. This allowed identifying gaps in current research and suggest areas for further research.

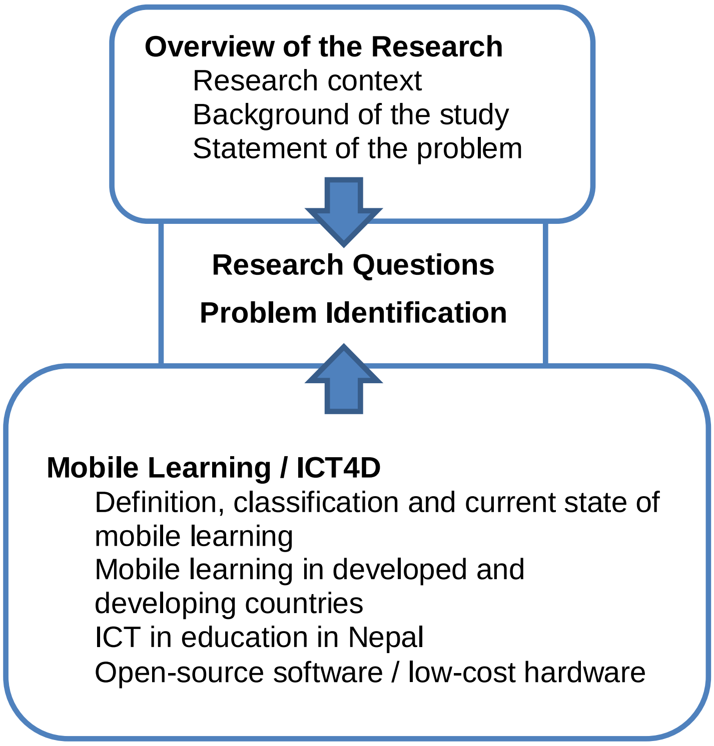


Figure 2: Literature Review Approach

At the beginning of a literature review process involved researching articles and books by scanning the UWL digital library which identifies relevant databases for every subject. However, due to an interdisciplinary nature of this research, information was retrieved from various fields of knowledge in the subject area of computing covering mobile learning, mobile HCI and ICT4D. The search was based on the main keywords (see Figure 3 for the initial list), its related synonyms and alternative terms as well.

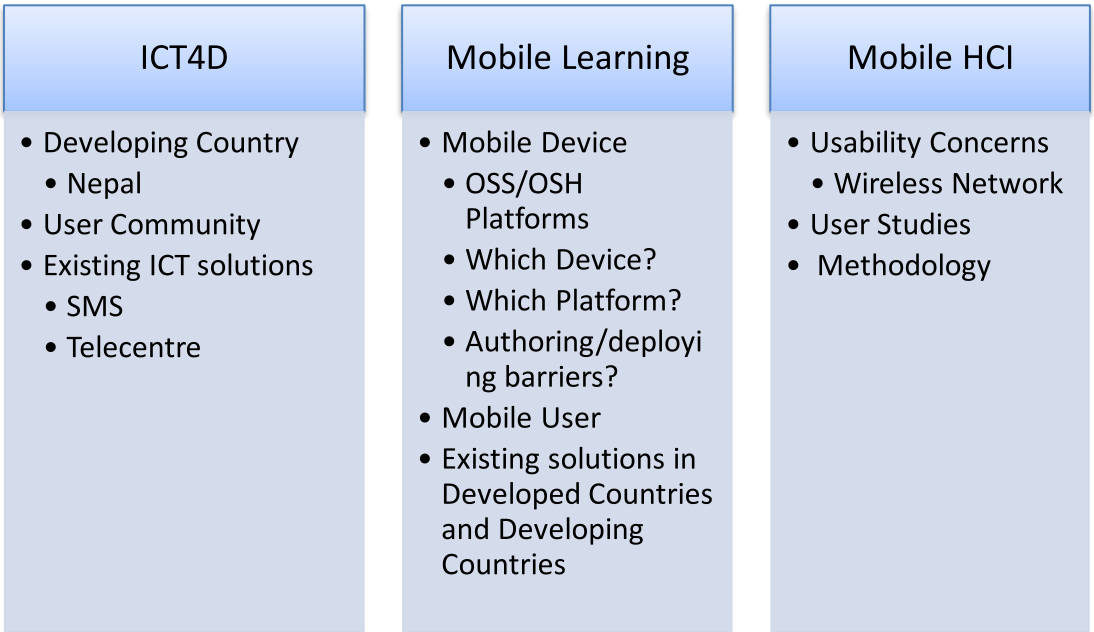


Figure 3: Keywords for literature review

Mobile learning is relatively a new field of research and the majority of literature on this topic dates from early 2000, while use of ICT for development goes back much further than that. So, literature search was not restricted to a specific period. Then the evaluation of the literature, analysis and synthesis provided both background and context to the area of this research study. But, the literature review was an ongoing process throughout the project to keep the review relevant and up-to-date. In the next chapter, contents are organised/discussed in relation to identified themes.

2.2 ICT4D

In this research study, information and communication technologies for development (abbreviated as ICTD or ICT4D) helps to broaden the understanding of the associated challenges in the process of implementing a technological intervention in the context of developing regions as there is clear evidence that ICT use does not by itself lead to progress (Islam and Grönlund, 2016).

ICT4D involves multiple sectors and draws interest from multiple disciplines. ICT4D attempts to understand and explain how information communication technology (ICT) leads to development. The "ICT has the connotation of modern electronic technology—the PC, the mobile phone, and the Internet play central roles" (Toyama and Dias, 2008, p.23). The development is however a complex social phenomenon (Dearden *et al.*, 2010) and arriving at a definition is far more contentious, and the field of development studies includes a very wide range of positions (Anokwa et al., 2009). As Dearden and Tucker, (2015, p.1) explained:

"Within the community of research and practice that is ICTD, the acronym is variously discussed as either: Information and Communication Technologies and Development or to Information and Communication Technologies for Development. The former construction 'and Development' is more easily associated with social scientific studies of the processes and consequences of technology adoption, whereas the 'for Development' formulation is often more for engineering practice and research which sets itself the higher goal of devising technologies and establishing sociotechnical interventions that contribute toward Development."

While the mainstream discourse's conceptualization remains heavily focused on economic growth (Kleine, 2009), some on the millennium development goals (MDGs) and some concentrate on people's livelihoods, Amartya Sen's capability approach (CA) offers a way of thinking about development not as economic growth, but as individual freedom (Anokwa *et al.*, 2009). The approach is seen as a suitable framework to explore the link between ICT and development (Thapa and Sæbø, 2014). Sen identifies a range of types of freedom that should be considered: political freedoms (such as freedom of speech and democratic governance), social opportunities (such as education and social mobility), guarantees of transparency (from agents of government and other wielders of power), protective security (health care and other social safety nets), as well as the economic freedom in the form of opportunities and capabilities to earn or create a livelihood. All of these elements contribute to people's freedom to determine their priorities and to improve the quality of their own lives (Dearden *et al.*, 2010).

"As every aspects of our life in the 21st century is increasingly becoming digital, those without ICTs will be increasingly excluded" (Heeks, 2008, p.2). Pitula *et al.* (2010) identified three main thrusts of ICT for Development (ICT4D) initiatives, which are: (1) developing infrastructure to provide power, connectivity, and devices appropriate for the prevailing conditions in a sustainable manner; (2) building ICT capacity corresponding to the skills and competencies necessary to maintain and use the technology; and (3) providing digital content and services. "In addition to ingenious computing solutions that can a) operate in any conditions, b) over any platform c) with low maintenance needs and no budgetary implications, and d) using limited or intermittent power of the kind that currently fuels our appliances, the product is to be used by people with different understandings of knowledge, culture and the role of technology" (Dearden *et al.*, 2010, p.2).

Even though studies on digital divide indicate strong correlation between GDP growth and ICT investment (Walid, 2006; cellular-news, 2009), according to Sey *et al.* (2013, p.68), "having access to knowledge resource does not necessarily mean that there will be a corresponding change in social and economic conditions of the people who have been blessed with such access as such change does not usually happen in a simple and linear cause and effect scenario". Therefore as Shields (2009) highlighted, though the presence of ICTs and network access is generally necessary for information access, it is not sufficient due to the complex and convoluted relationship among information technology, information access, and development. "Due to the difficulty in identifying and isolating the factors that explain how ICT contributes to development, future research is needed to identify the challenges and potential benefits of introducing ICT for development" (Thapa and Sæbø, 2014, p.10). Thus, a first step towards a better understanding of the outcome of implementing mobile learning in a developing context is to identify and address the various challenges to design and sustain a mobile learning solution to support teaching and learning in a public education.

2.3 Defining mobile learning

Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies (O'Malley et al. 2003, cited by Sharples, 2013, p.3)*.*

A number of mobile learning research studies carried out with the aim to improve teaching and learning are increasing (Traxler, 2009). In general, mobile learning explores mobile devices capabilities to identify the learning opportunities and locating distinctive features of learning with mobile devices is an evolving process as technologies mature (Kearney *et al.*, 2012). Portability, social interactivity, context sensitivity, connectivity and individuality are five unique affordances of mobile devices (Klopfer et al. 2002 cited by Naismith *et al.*, 2004), which inspires a development of a mobile learning solution.

According to Dyson *et al.* (2010), so far, the theories of mobile learning are either built on contemporary learning theories or by examining the distinctive affordances and use of such mobile devices. While mobile learning has been defined from the narrow techno-centric view, mobile devices were seen as a medium to deliver learning, or to support e-Learning in a formal or traditional education setting. "Such definitions merely put mobile learning somewhere on e-learning's spectrum of portability and also perhaps draw attention to its technical limitations rather than promoting its unique pedagogic advantages and characteristics" (Traxler, 2005, p.263). In fact, with many opportunities/complexities that it offers, mobile learning has been described as "noisy" and problematic (Traxler, 2009). Due to its complex nature, there is still a lack of a coherent conceptual/theoretical frameworks, methods and tools to understand, analyse, explain and theorise its practices (Vavoula and Sharples, 2009; Pachler et al., 2010; Kearney et al., 2012;Sharples, 2013). For the effective assessment, pedagogy, and design of new applications for learning, there still remains a need for the widely accepted mobile learning theory (Pachler et al., 2010). A theory of mobile learning that can be used to inform educational design by taking learners' experiences perspective and using pedagogies appropriate for mobile learning (Dyson *et al.*, 2010;Traxler 2007 in Kearney et al., 2012).

Now, wider exploration of mobile technologies is increasing to identify educational benefits in and outside classroom and as part of everyday life and a mobile device is seen as a mediating tool to guide learner's knowledge construction process (Winters, 2007; Pachler *et al.*, 2010). As Traxler & Leach (2006, p.1) described "mobile learning is the term increasingly being applied to the use of small, portable, handheld and lightweight electronic devices used for educational activities in classrooms, in fieldwork, at home, at work and when travelling". It defines mobile learning by considering the mobility of a portable *technology*, the *learner* and the *information* in various contexts to support learning activities. With the change of focus from the technology alone to the mobility, mobile learning has essentially become informal, personal, contextual and situated delivering learning experiences (Traxler, 2007, 2011b). Therefore, mobile learning is expected to deliver learning experiences by extending education outside the classroom. Sharples *et al.* (2009, p.237) considered these mobility and contexts aspects to define mobile learning:

'Mobility' of learners is augmented by personal and public technology and 'context' is continually created by people in interaction with other people, with their surroundings and with everyday tools. Thus, mobile learning is characterised as the processes (both personal and public) of coming to know through 'exploration' and 'conversation' across multiple contexts amongst people and interactive technologies. A learner explores by moving physically or through the conceptual space, linking the experiences and concepts into new knowledge and connects learning across contexts through conversation.

To enable such explorations and conversations, the need is to open up the formal teaching and learning practices of educational establishments to learning in informal contexts. Therefore, Winters (2007); Pachler *et al.(*2010) suggest adopting new cultural resources (mobile devices, contexts and content) into school-based learning and pedagogical practices to harness the learning that takes place in everyday life as the result of the active transformative engagement with those resources where meaning-making is seen as an integral part of learning. According to Winters(2007); Pachler *et al.* (2010):

Mobile learning is the processes of understanding and knowing how to utilise our everyday life-worlds (the environment, the lifestyle and habitus) as learning spaces and being able to operate successfully in, and across, new and ever changing contexts and learning spaces.

In the proposed ecological approach, (Winters, 2007; Pachler *et al.*, 2010) highlighted the interrelationship of three components (*agency*, *cultural practices* and *social structures*) to conceptualise the mobile learning. In this approach, learning with mobile devices is understood as a process of meaning-making within socio-cultural and technological structures that govern their being in the world; cultural practices - the routines users engage in their everyday lives; and agency - the user's capacity to act on the world (see Figure 4).

With this high level theoretical definition, the focus of mobile learning has changed from simple mechanisms of content delivery using mobile technology to that considers the characteristics of mobility of learner from formal classroom to informal contexts. However, Dyson *et al.* (2010) argue that it is still insufficient to create an active learning experience that deeply engages students. They highlighted the need for mobile learning to incorporate sound educational design principles and a theoretical underpinning which reinforces the need for learner engagement through active student-centred experiences. But to exploit and integrate the various ways that mobile devices can be used in education and leverage its benefits, it is important to understand the complex nature of mobile learning.

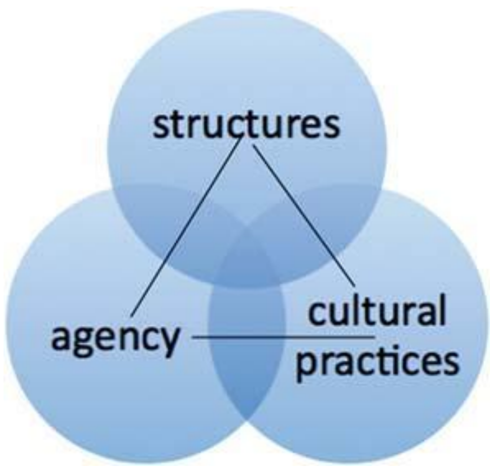


Figure 4: the Socio-cultural Ecology: Agency – Cultural Practices – Structures (Winters, 2007; Pachler *et al.*, 2010)

Koole, (2009) definition of mobile learning which sits well with socio-cultural views of learning (Kearney *et al.*, 2012) that describes mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction (Kenny et al. 2009; Koole & Ally 2006; Koole, 2009).

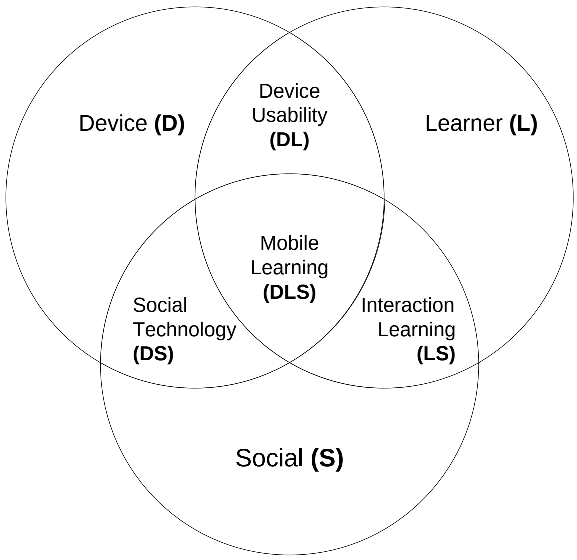


Figure 5: The FRAME model (Koole, 2009)

This model (see Figure 5) has been developed as a complete framework that provides the criteria and examples of each aspect and interaction and the checklist that might help educators plan and design mobile learning environments (Park, 2011). Use of such framework provides the focus on the essential aspects of mobile learning. There are set of three intersecting circles representing the **device** (D) which describes characteristics unique to electronic, networked mobile technologies; **learner** (L) describes characteristics of individual learners; and **social** (S) aspects describes the mechanisms of interaction among individuals (Koole and Ally, 2006) as learning is not an exclusively individual process and is affected by the interaction and communication with others such as learners and teachers (Frohberg *et al.*, 2009). The overlapping intersection of the FRAME model representing the **device usability** (DL) and **social technology** (DS) describe the affordances of mobile technology; the **interaction learning** (LS) contains instructional and learning theories and the primary intersection (DLS) in the centre is a convergence of all three aspects, defines an ideal mobile learning situation that provides enhanced collaboration among learners, access to information, and a deeper contextualization of learning (Koole, 2009).

As research and practice in mobile learning are still in their infancy, mobile learning is still new and rapidly growing as a discipline (Sharples, 2013)and the lack of common understanding (Frohberg *et al.*, 2009) shows the complexities that surrounds this field. However, “design of mobile learning still needs a clear understanding of ever changing technology, the related challenges and learning opportunities it provides, learners’ and teachers’ specific characteristics, needs, preferences, expectations, their roles and beliefs and characteristics of the environments that influence the learning experiences” (Kearney *et al.*, 2012). Therefore, this research study is planned (as discussed in the chapter of Research Methods) to develop the valuable insight from a socio-cultural perspective which will have a practical applicability and guide deployment of initial research in mobile learning in a developing country Nepal.

Table 1: Mobile learning classifications from different perspectives (Source: Author)

Contingent mobile learning	Situated learning	Authentic learning	Context-aware learning	Personalised learning	Learning based on user-generated contexts	Game-based learning and Assessment
Mobile Learning Achievements based on technology and pedagogy (Traxler, 2011b)						
High transactional distance socialized m-learning	High transactional distance individualized m-learning	Low transactional distance socialized m-learning	Low transactional distance individualized m-learning			
Pedagogical framework (Park, 2011)						
Behaviourist	Constructivist	Situated	Collaborative	Informal and lifelong	Learning and teaching support	
Pedagogical theories (Naismith *et al.*, 2004)						
Learning management applications	Supportive applications	Content-based applications	Context-based learning applications	Collaborative		
Usability(Deegan and Rothwell, 2010)						
Technology-driven mobile learning	Miniature but portable e-Learning	Connected classroom learning	Informal, personalised, situated mobile learning	Mobile training/ performance support	Remote/ rural/ development mobile learning	
Technology & pedagogy (Traxler, 2007)						
Free Context	Formalised Context	Digital Context	Physical Context	Informal Context		
Context: Where the learning takes place (Frohberg, 2006)						
Permanently online	Frequently online	Offline				
Connectivity (Traxler, 2005) (Georgieva et al., 2005) (Fu and Ding, 2008):						

2.4 Classification of Mobile learning

As the capabilities of a mobile technology continue to improve, it also increases the possibilities of designing an effective mobile learning to suit a varied learning context. The nature of mobile learning is such that it is difficult to develop the broad classification that includes all of its aspects and there is no one theory of mobile learning that fits in every situation. Therefore, mobile learning and its applications have been classified from different perspectives and a specific mobile learning solution may belong to different groups due to similar characteristics (see Table 1 above).

Mobile learning practices varies from formal - in the classroom and informal - out of classroom such as museums and zoos, from a fixed to anytime/anywhere learning and also integrating into society enhancing the social interactions. Therefore, there are various categorisations of mobile technologies and learning based on different characteristics of mobile devices, learners and the context of use. There are classifications base on connectivity (Traxler, 2005); Usability (Deegan and Rothwell, 2010); pedagogical theories (Naismith *et al.*, 2004); based on how technology has been deployed (Traxler, 2007); mobile learning achievements (Traxler, 2011b); based on *context* which is the most persistent characteristic in mobile learning (Frohberg, 2006) and in the context of distance learning (Park, 2011).

Though selective, the mobile learning classifications mentioned in the figure 3 above shows that the general focus of such classifications have been on the different aspects of the technology used and/or the pedagogy that it supported. These categorisations are made based on different types of mobile learning solutions implemented or deployed in varied contexts to support different types of learning activities, their usability and also the learning theories. "Classification schemes such as the mobile learning framework are helpful for the understanding of mobile learning, for guiding the development of future projects and for research in the field, but need to be continually revisited to allow the integration of new projects and emerging trends" (Marston and Cornelius, 2010, p.74).Though, there are some overlaps or similarities between the categories, a specific project cannot be equally positioned in several categories (Frohberg *et al.*, 2009). But, these categorisations highlight the underlying specific issues, challenges and benefits of mobile learning that allows developers make better informed design choices by considering both the technologies used and the various contexts of the learner aspects. It helps to design a mobile learning solution by maximising the identified benefits, reducing the related issues and thus increasing the chances of successfully embedding the solution in to the educational context where it is expected to be used.

2.5 Selection of mobile devices

Before proposing, developing and piloting a mobile learning solution, the importance of considering an appropriate target mobile platform to deliver and support learning is one of the key aspects of a sustainable design. But, “interestingly enough, research efforts in mobile learning field have seldom reported on problems and limitations or different types of barriers and constraints” (Traxler and Kukulska-Hulme, 2015, p.155). Mobile learning researchers in every sector and in many countries are focusing on integrating feature-rich smart high-end mobile devices (such as iPhone, iPod Touch and Tablets) (see Figure 6) into schools and universities and delivering learning resources to meet students' academic needs. But, building applications on these devices mean using the controlled proprietary platform that restricts development. Also, most of the recent mobile learning pilots and projects generally relied on provided or loaned smart mobile devices to identify the usefulness of such technologies.

An iPhone application such as iStanford (Pena 2009) from Stanford University was developed to disseminate learning services and also by Curtin University of Technology (Robinson et al. 2009), which has again utilized the iPhone and its subsequent operating system as their platform of choice (Crane & Benachour 2010).

Low-end phones	High-end phones	e-Book readers	Tablets

Figure 6: Examples of mobile devices used in mobile learning

As part of university initiative to encourage creative usage of technology in education and campus life, Duke distributed 20GB Apple iPod devices to over 1600 entering freshmen in August 2004 (Duke Digital Initiative 2004). In the fall of 2008, Abilene Christian University became the first university to distribute Apple iPhones and iPod Touches to incoming freshmen of the university, allowing people to explore a new vision for mobile learning (Duke Digital Initiative 2004).

Similarly, to explore the viability and effectiveness of a mobile teaching and learning environment that would take advantage of mobile phone access to internet instructional materials, iPod touches were provided to students through the college fund (Tien & Boston 2010). To investigate how best to use mobile technologies in learning and teaching, community of higher educators was formed and the project funded the purchase of iPod touches (Schuck et al. 2010). On the development of a mobile learning portal at University of East London (UEL), trails for evaluation were planned by providing devices with Wi-Fi capability to students through project funding (Olasoji & Draganova 2010). Most recently, examples of institution-wide m-learning transformations projects such as a three-year iPads-for-learning initiative (2012-2014) at the University of Western Sydney (UWS) purchased 45,000 iPads for distribution and students appreciated the flexibility iPads afforded (Rankine-Venaruzzo & Macnamara, 2015).

Even though high-end smart devices offer a truly innovative multi-touch interface applications and applications based on these devices may prove to be highly successful, with their choice of exclusive medium, do restrict the amount of penetration in a vast and varying mobile market (Crane & Benachour 2010). Moore et al. (2009) explored capability of the iPhone as an offline learning tool. The goal of the software was to allow documents to be located during an Internet search and then cached on the device to be read offline. To facilitate offline access to these documents a powerful open source search engine was ported to mobile architectures. This provided an efficient method of locating documents using familiar keyword searches which scaled beyond traditional file browser approaches. In addition, it allowed documents to be easily located despite having ambiguous file names. The authors faced significant challenges during development which required "jail breaking" the device. Thus, although storing, searching and accessing documents locally demonstrated potential for a powerful offline tool, from a developer perspective, developing solutions for a locked down device restricts creative and innovative development (Moore *et al.*, 2009). Within the context of ICT4D, inexpensive (cost-effective) platforms can facilitate rapid application development (Ledlie et al. 2009) and open platforms can provide unlimited choices for developers and ultimately for end-users.

According to Traxler (2010), mobile learning approach centred on student devices is challenging and radical for institutional IT units. “The challenges include equity, standards, quality assurance, infrastructure, security and embedding and blending with institutional blended learning” (Traxler, 2011a, p.5). He also highlighted that “from a methodological perspective, it is easier with a homogeneous and predictable technology platform and also easier from a staffing and infrastructure perspective since planning and training are comparatively straightforward. It does however mean that most mobile learning pilots and projects are unsustainable because they are predicated on finance in order to provide subsequent cohorts of students with devices”(Traxler, 2010, p.12). Thus, even though use of the latest mobile technologies can have significant impact on teaching and learning, assessment of the issue of cost in the long term is important to sustain the solutions.

Also, ownership of the technology is equally important in mobile learning. Corlett *et al.* (2005) found that whilst the PDAs were loaned, students were reluctant to invest time and money in personalization and extension. Similarly, from experiences in early pilots, Traxler (2010, p.78) suggested that “students were not likely to value a second, university-provided device that did not express their taste or aspirations and that it would inevitably be the one left at home”.

However, in a recent study Reid and Pechenkina, (2016) investigated student experiences with and preferences for mobile learning technology, accessible via BYOD ('Bring Your Own Device') or a prescribed approach. The study investigated student experiences with and preferences for mobile devices, depending on whether those were loaned or owned. The study revealed that students tended to use their owned and loaned devices simultaneously and in a complementary manner rather than choosing to use one device for all learning activities. But it recommends further research to evaluate the impacts of BYOD versus prescribed technology on student learning.

Some of the current studies also highlighted the issue of affordability, while students were required to pay for the service. StudyTXT (McGuigan*et al.*, 2010) – a SMS based supplementary learning tool within an introductory accounting decision-making course was implemented in order to assist students who may like to download 'bite-size chunks' of information prior to the term test and final examination. The most conclusive reason for respondents' discouragement of StudyTXT's use was the perceived high cost associated and was a barrier to its widespread usage. Similarly, another study of using SMS to enhance students' learning experience in the course highlighted the issue of cost that may prevent both the instructor and students from further using it, especially if an interactive mode is adopted (Santos, 2010). In a recent quantitative study (Ismail et al., 2016) within Malaysian higher education setting on students' readiness for the integration of mobile technologies in education system found that the implementation of mobile learning was still not widespread due to several factors, such as cost issue, pedagogical and technological challenges as well as policy constraint.

Even though a growing number of practical experiences with mobile devices are becoming available as a result of their increased use in formal education (Bachmair and Pachler, 2015), there are many more examples of research studies reporting problems and limitations of mobile devices to support teaching and learning. Despite its flexibility and affordability, mobile learning is still in early development stages with both technological and pedagogical limitations (Liaw, Hatala and Huang, 2010 cited by Jalil *et al.*, 2015). Therefore, there are only few research efforts that have succeeded in integrating mobile devices, that are able to innovate pedagogical practices in sustainable ways and that have resulted in the implementation of useful learning tools that are wide in use (Traxler and Kukulska-Hulme, 2015). In the recent study of the changing study practices of 1700 UK distance learning students using new portable digital devices such as tablets, e-books and smartphones into their learning at The Open University by the E-Pedagogies Project between 2012 and 2016, Cross et al. (2016) highlighted the need for further research in to widespread student use and adoption of handheld devices. The study demonstrates the relative lack of use of tablets, and to a lesser extent smartphones, for study purposes which shows an underutilisation of this technology and that there remain barriers. The study therefore highlights the need to research and develop flexible pedagogies, learning designs and resources that allow students to take control and adapt their learning to the specific mix of technologies and locations in which they study.

2.6 Mobile learning in *developing countries*

"'ICT for Development' grew in the past decade due in part to the promise of the newer computing technologies; the idea of leapfrogging technology (off-the-shelf solutions) that could be replicated in developing countries poor communities" (Toyama and Dias, 2008, p.23). But "computer resources remain greatly overstretched, especially in primary schools. According to data from the UIS database, in Egypt, Nepal and the Philippines, over 100 learners share a single computer at the primary level" (UNESCO, 2015, p.211). However, mobile phones have the greatest potential for delivering ICT-based learning in the developing countries. In fact, "mobile learning is gradually gaining on popularity because of the increasing availability of low cost mobile and wireless devices as well as the supporting infrastructure and technology" (Jalil et al., 2015, p.1).

To reduce the digital divide by providing access to information and knowledge, Telecentres were initially prompted as a tool for communication and sharing of information and knowledge in developing countries (eAsia, 2009). But such shared or community-level access programs have little chance for success in Nepal's circumstances. In 2004, Nepal government created 80 telecentres to push sustainable technology to its people. Five years later, most telecentres struggle with sustainability due to issues of gender norms, generational distrust, lack of awareness, funding, lack of training and time. And also challenges related to location, power, and connectivity (Lee *et al.*, 2014).

The telecentre model has encountered many difficulties, mainly because of poor telecommunications access, high access costs, due to the local conditions (lack of electricity, lack of maintenance skills, etc.), the initial costs of setup and running, and, as a result, very few reached long-term sustainability and operation (Shields, 2009; Boyera, 2009). According to Heeks (2008), such educational development efforts often resulted in failure, restriction, and anecdote, which in turn highlighted the importance of developing sustainable and scalable solutions and interest in objective impact evaluation.

Considering the characteristics of physical infrastructure of a developing country Traxler and Leach (2006) and Heeks (2008) pointed out the need for hardware innovations and develop the type of low-spec, low-cost, low-power consuming robust terminal device and better wireless infrastructure for pushing forward the Internet-connected PC. Hence, Traxler (2007, p.3) highlighted the need for a different mobile learning approach in the developing region's context due to "environmental and infrastructural challenges to delivering and supporting education where 'conventional' e-Learning technologies would fail, often troubling accepted developmental or evolutionary paradigms." As Traxler (2007, p.2) refers to Traxler and Kukulska-Hulme (2005) to highlight: "the radically different physical infrastructure and cultural environment – including landline telephony, Internet connectivity, electricity, the rarity of PCs, and the relative inability of societies to support jobs, merchandising, and other initiatives based around these prerequisites – has meant that prescriptions for mobile learning are more cautious than in the developed world". As they distinguished a separate category of '**remote/ rural/ development mobile learning**'

(ML4D), it highlights the need for specific guidelines to assist mobile learning deployment in developing countries such as Nepal.

In the literature, researchers are increasingly acknowledging the fact that mobile phones are rapidly becoming pervasive and for a large group of people (especially in the poorest regions) mobile phones are the first and only interactive digital media they directly operate and experience (Heeks, 2008; Joshi and Avasthi, 2007). Potential of mobile technologies is also increasingly being explored as a new range of hardware platforms on which innovative systems may be built to help bring services and new opportunities to the poor (Dearden *et al.*, 2010). There are examples of how simple handsets and networks are beginning to produce indispensable services such as M-PESA (Hughes and Lonie, 2007) in Kenya and Healthline (Rahman, 2007) in Bangladesh. As Education for all impact report (UNESCO, 2015) highlighted an adult education programme in Niger where mobile phones were used for exercises improved reading and numeracy outcomes significantly more than in programmes without mobile phones. The MoMath Project with 25,000 learners accessing mathematics content via mobile phones in South Africa, led to a 14% increase in mathematics skills. Similarly, in the United Republic of Tanzania, the BridgeIT programme allowed teachers to download videos on subjects such as science and mathematics on a mobile phone and transfer them to a television in the classroom, which led to improvement in grade 5 students' mathematics and science scores and in classroom interaction, with students asking more questions and working together (Enge, 2011 in UNESCO, 2015). Hence, there are evidences of improving mobile access in developing countries and a mobile technology's central role in bridging the digital divide.

Though the variety of mobile devices and software platforms provide numerous options to design and develop mobile learning and every context (developed or developing countries) present unique set of opportunities to implement mobile learning, there are also considerable challenges to introduce a technology to support education. There are numerous examples of mobile learning initiatives from around the world that have highlighted the benefits of mobile learning. But, beyond short-term pilot studies that identify specific benefits and issues, "one over-riding concern that remains today is the problem of moving projects and pilots into the mainstream of educational provision and finding secure and sustainable funding and support" (Traxler and Leach, 2006, p.3).

Even though GPRS/3G networks and handsets are coming down in cost and the exploration of the use of portable mobile technology is increasing in developing regions, developing interactive learning solution for the widely available basic mobile devices is challenging and the use of expensive smart phones is not yet common. The costs to implement sophisticated telephony systems can be prohibitive (Chhanabhai and Holt, 2009) and the innovative mobile web & broadband services also require next generation mobile broadband technologies and advanced terminals for a successful launch and operation (Mekuria, 2009). As the cost of the device is one important factor, only inexpensive platforms can facilitate rapid application development (Ledlie *et al.*, 2009).

There are examples of projects in developing countries that throw considerable light on issues of sustainability and scale as the projects face challenges to extend their scope and their impact (Traxler and Leach, 2006) as they taken similar approach of developed countries to deliver mobile learning. In one of the studies in Sri Lanka, a company (Dialog GSM) provided mobile phones to study the use of mobile phone cameras in science teaching and learning. In this pilot study, schools did not have adequate funds to acquire mobile phones for one-to-one use (Ekanayake and Wishart, 2010) and sustain the mobile learning initiative.

In Bangladesh, the ‘English in Action’ a nine-year (2008-2017) English language teaching education program was launched in 2008. It provided iPods for teachers from rural schools to use in the classroom at its initial phase. The aim was to identify the effective, scalable and sustainable model of supported Open and Distance Learning for English Language Teachers, and the most appropriate forms of mobile technology to support this (Power and Shrestha, 2010). Such teachers often work in the most challenging situations, with large class sizes, grade repetition, extremely limited teaching resources, poor infrastructure and high exposure to seasonal or environmental strains. However, authors argued that it was necessary to conduct this developmental research to explore how such technologies can be used to support English language teaching in Bangladesh, which was based on the forecast that mobile technologies will be widely available and affordable, capable of supporting language learning activities and practices, within the next 3 to 6 years. But the mobile learning designs locked into a certain technology platform or based on assumptions such as there is or will be a wider availability of a specific platform and the ubiquitous connectivity (Parikh and Lazowska, 2006) are current and relevant technical challenges for mobile learning long term development.

Even though ‘KrishiPustak’ (Gupta *et al.*, 2015), an audio-visual social networking (SN) based mobile application was useful and usable and allowed low-literate farming populations in rural India to make posts and replies using audio-visual content, the outcome of the study was completely dependent on the loaned device (Nokia Lumia 820) which was provided to the mediators (agriculture extension workers of a non-profit organization). Therefore, the use of the system was driven by how mediators described it should be used and there was a very limited use for other social networking activities. By exploring the non-mediated use of such applications with improved user-friend functionalities based on farmers owned device could highlight the challenges to scaling and sustaining such systems.

Digital StudyHall (DSH) (Anderson *et al.*, 2012) which facilitated video-based lessons for primary school education in low resource settings, regardless of initial positive growth in pedagogical development of participating teachers and students, it faced significant obstacles to scalability and sustainability. During the 2 years long study period, the intervention was sustained only by regular monitoring and support which would not be possible to maintain in a scaled deployment. The study highlighted teachers’ low perception of their profession, government’s lack of respect to their profession and lack of incentives to actually teach, lack of institutional support, infrastructure and frustration dealing with illiterate parents who did not see the value of education were the major challenges to scalability. Technology is therefore just a tool and it faces complex challenges to contribute to a positive outcome. The project itself has proven difficult to evaluate quantitatively (Cutrell *et al.*, 2015).

A relatively affordable Talking Book (Schmidt *et al.*, 2011), a portable and battery powered unique form of a mobile device was designed as a personal device especially for people who cannot read and who live without electricity. A unique characteristic of this device was that it allowed device to device sharing the vital knowledge among poor, rural communities. It allowed farmers apply their new-found knowledge and had an average increase in crop production compared with the non-user's decrease. Local experts could also use this device to spread knowledge reliably and easily with no information loss and rural teachers complemented their lessons with interactive applications and audio books. Therefore, a system based on a well-designed cost-effective mobile platform with the understanding of a local context has a better chance of successfully scale and sustain.

Comparatively, developing countries present challenging environment to introduce technical solution than developed countries, but the need for information communication technology for development is crucial in both contexts. According to Toyama and Ali (2009), “the technologies developed for the first world have often been a poor fit in these areas, due to issues of cost, infrastructure, physical environment, and social factors, and there is a need for technology research specially aimed at developing regions”. Thus, the use of mobile based solutions are yet to improve as the lack of infrastructure and limited purchasing power demand not just to develop low-cost approaches and the replicable hardware that can be appropriated and adopted by community-based organizations with minimal requirements for external support (Ho. *et al.*, 2009) but also serve the unique needs of developing regions and populations.

XO	Classmate PC	Simputer	Netbooks	Talking Book	Aakash Tablet

Figure 7: Examples of educational technologies

There are on-going efforts focused on developing the type of low-cost device (see Figure 7) that could work in variety of learning contexts and also in large numbers of poor communities. Interestingly, regardless of different initiatives targeted for developing worlds, the expectations are not met (Pal *et al.*, 2009). One of the well-known initiative, One Laptop Per Child (OLPC, XO) has failed to take off partly because of its costs US$200 (£141) to make.

"Uruguay has achieved a universal 1:1 learner/computer ratio: 362,000 students and 18,000 teachers in public schools had their own portable computer by 2009; all primary teachers received training and had access to an educational portal with resources. However, the program has not been found to significantly improve mathematics and reading scores" (de Melo et al., 2014 cited by UNESCO, 2015, p.212). "In Peru, the One Laptop per Child programme had no impact on test scores in mathematics and language, but improved verbal fluency, abstract reasoning and processing speed" (Cristia et al., 2012 cited by UNESCO, 2015, p.212). It has been also been criticised as a techno-centric initiatives to bridge the digital divide and for not taking a holistic approach (Thapa and Sein, 2016).

According to Kraemer *et al.*(2009, p.66), “it has however motivated the PC industry to develop lower-cost, education-oriented PCs, providing developing countries with low-cost computing options directly in competition with OLPC’s own innovation”. While the locally developed and open handheld hardware 'Simputer' which was cheaper than US$35, yet sold a mere 4,000 units in 2005 and disappeared without a trace (Pal *et al.*, 2009), Recently, the Indian government unveiled an ambitious project to develop yet another cheapest laptop computer, a touch-screen device that will cost US$35 (Halliday, 2010). But the future of such an ambitious initiative is not known and positive educational impact cannot be guaranteed. The technology is evolving and it’s a challenge to compete in the market that rushes to produce the innovating solutions continuously. In the economically challenging context, the social and cultural barriers add complexities to implement technologies for educational or developmental purposes. However, development of such accessible hardware increases the possibility to improve access to internet and potential to provide a wider access to digital resources.

In an international literature review of 1:1 computing in schools, Islam and Grönlund, (2016) considered all the devices used including laptop and also low-cost PCs (e.g. OLPC’s XO and Intel’s Classmate PC), tablet computers, and handheld tools (e.g. smartphones and iPod Touch). They also considered all countries in the world, irrespective of level of development. They highlighted the need for a shifting research focus as the multitude of devices coming into use and the increased role of networked resources in teaching and learning. Therefore, the review points out the focus should not only be on pedagogical methods but also school organisation and leadership and their contribution to improving and disseminating good pedagogy and dismantling bad habits.

While the impact of technology cannot be confidently guaranteed to improve education and change learning for better, the selection of appropriate technology is a crucial aspect of mobile learning design. The studies presented in this thesis are attempts to recognise the clear need to understand the potential (benefits and limitations) of a technology which is not necessarily the smartest or the expensive technology available in the market and design mobile learning based on the low-level investigation of the learning context. Therefore, this research explores how a mobile learning approach using open-source platforms may be used to support teaching and learning in the context of public schools of Nepal and identify the challenges that need to be addressed for a sustainable mobile learning design.

2.7 ICT in education in Nepal

Since 1992, Nepal has undertaken a number of policy initiatives in the ICT sector positioning IT as a tool for development and growth. The recent draft of National Information and Communication Technology (NICT) Policy 2015 primarily aim to guide and mainstream the use of ICT in all sectors to reduce the development divide and increase the chances of improving the quality of life of the citizens. Ministry of Education (MOE) of the Government of Nepal (GON) plans to ensure an extensive use of ICT in the education sector and increase access to and quality of education for all (MOE, 2013b). The main goals of ICT in Education Master Plan 2013 - 2017 are 1) to expand equitable access to education; 2) to enhance the quality of education; 3) to reduce the digital divide; and 4) to improve the service delivery system in education. So far, despite the strong commitment to use the ICT in education in the policy level, the technology faces many challenges to become a central in teaching, learning and schools' administration of Nepal.

Currently, there are few Nepali non-profit organizations developing digital educational resources. Kul Techno Lab and Research Centre provides a Kullabs Smart School[4] e-learning platform to offer a free e-learning educational content useful for schools. MiDas eCLASS[5] has developed offline Teaching and Learning software (available in the form of Android Apps also) that has Tutorial Videos and Interactive Games of all chapters of the book that students study in their schools. But their contents are not free. Open Learning Exchange (OLE) and Nepal Wireless Networking Project (NWNP) are working towards improving quality and access in Nepal's public education system mainly focussing on OLPC laptops. Since 2008 they have been in a testing phase of using the network for online-based learning (Sæbø *et al.*, 2014).

OLE Nepal creates interactive educational software (e-Paath), that are closely aligned with the national curricula and a digital library (e-Pustakalaya) which can be accessed online or installed locally. In 2015, a mobile e-Pustakalaya android application was also lunched which allow accessing the library online or on local offline servers within the Wi-Fi network where the server is installed. To support schools use these

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[4] Kullabs Smart School https://www.kullabs.com/
[5] MiDas Education http://midaseclass.com/

solutions, OLE Nepal also help deploy technology infrastructure in under-resourced rural schools and provide teacher training to improve teaching-learning process and enhance education using technology.

The locally-initiated so-far successful (NWNP) has been using ICT to develop and extend the social capital, which assists people in developing and improving their education, healthcare, communication, and generating economic activities (Thapa and Sæbø, 2011). The project is exploring Wi-Fi technology to bring internet to the villagers since 2002. NWNP has connected more than 175 remote villages in 15 districts of Nepal until 2013 mainly working with schools, health clinics, hotels and community centres and planned connecting 15 more villages of Gorkha, Tanahun and Myagdi districts in 2014. Using the power of Internet, the project aims to maximise the benefit of the technology to the rural population by providing tele-education/training, tele-medicine, email and internet telephony, information sharing and e-business services such as Internet banking and remittance services. But as Thapa and Sæbø, (2011) highlighted the challenge is to sustain the future of this project due to over dependency on a single actor, a high illiteracy rate, poor physical infrastructure, political instability, and lack of participation, all of which may hinder the development process.

In the early 2004, World Bank funded mobile library project called Sustainable Doko Dai Mobile Library project (SDDMLP). It was a mobile learning project without mobile devices which instead used the familiar pre-existing networks of dais (local porters) to carry/transport books, newspapers, magazines in Dokos (traditional cane baskets used to carry necessities) in participating remote villages of Nepal. The current status of the project is unknown. However, it highlighted the challenges of mobility presented by Nepal's hilly terrain.

According to UNESCO (2015, p.211), "Older technology continues to play an important role in improving learning and narrowing gaps in achievement for children in isolated or underserved settings" and radio programming is one such example of an enduring and successful technology". Since 2007, RadioGuru[6], a FM radio based solution developed by a Cambridge-based charity has been broadcasting pre-recorded lessons based on the current Nepali curriculum in mid-western Nepal. In late 2013, Radio Guru's curriculum content was improved to meet the needs of learners in their final year of secondary education. It shows the possibility of reaching underprivileged communities by using readily available technology.

The use of mobile phones for delivering healthcare services are increasing. According to Sajjad and Shahid (2016), results show the outcome of these types of mHealth programs is quite positive and applications such as Mobile Midwife, Text4Baby, and Mobile Ultrasound Patrol (Morocco), Baby+ (Pakistan) are designed to support pregnant women in developing countries. They also highlighted (p.2): "socioeconomic background of pregnant women living in developing countries and their expectations from technology are quite distinct. Therefore, there is a need to design more specialized healthcare solutions depending on the norms and needs of the local population."

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[6] Radio Guru http://www.mountain-trust.org/guru

In Nepal's context, Amakomaya[7] (Mother's love) is a comparatively advanced web/mobile application that allows health workers to track the stages of a woman's pregnancy by providing regular information and updates via text. It also provides educational video and audio programs about prenatal care for the expecting mother. It allows downloading the audio and video content and save in a mobile device according to woman's pregnancy week or can download all the audio and video contents at once from near health post where there is internet available.

Working with a couple of local charities, the Institute of Art Design and Technology[8] (IADT) from Ireland has deployed School in a Box (SIAB), a mobile solar powered digital education project in Yalbang School of Upper Humla which is one of the most remote and least developed regions of Nepal. The box includes an iPad with pre-loaded learning applications and content, which can be connected to a small lightweight projector powered by a solar battery and solar panel that can provide 5 hours of projection time.

Beyond this handful of initiatives, mobile learning in Nepal is still new and unexplored. Though the mobile penetration rate has increased from 5% in 2007 to more than 70% in 2014 and now crossed well over 90%, the national level policies do not explicitly address the use of mobile devices for education and has yet to emerge. In fact, according to So (2012, p.6) "no countries in Asia have ICT or education policies in place that specifically address mobile learning, implying that mobile learning is still a relatively new phenomenon and has not yet garnered attention from education policy-

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[7]Amakomaya http://www.amakomaya.com/

[8] School in a Box http://www.iadtschoolinabox.com/

makers." Despite a great potential for growth and development, mobile learning activities are scarce in Nepal.

2.8 Open-source software

Today, the technologies design and development through rapid innovations are continuously integrating and influencing all aspects of modern society. The uninterrupted access to information is the crucial requirement to be economically productive and develop a viable solution. Thus, the issues of affordability and intellectual property rights are of serious concerns. While *copyright* protects documentation from unauthorized copying, modification, and distribution, *patents* play a significant role in controlling right to make, distribute, or use a product based on that documentation. But the legal or illegal activities of sharing and remixing software and also copying the physical design of hardware have remained serious concern for IP owners. As the Noble prize winner economist Joseph Stiglitz sad, "the tight controls on IP rights in developed nations do not benefit technological infrastructure that is still developing" the question is regularly raised if it is worth protecting IP or should industry embrace the openness. The issue is complex and there is no straight forward answer. However, the open-source model promotes sharing of information to drive innovation and development of the technology.

In the world of mobile technology, there are many different devices with different screen resolutions running on different platforms and platforms have been proprietary and scattered. There are a variety of operating systems such as Symbian OS, Microsoft's Windows Mobile, Linux, iPhone

OS and many other proprietary operating systems. According to Hashimi and Komatineni (2009), supporting standards and publishing APIs would greatly encourage widespread, low-cost development of mobile applications, but none of these OSs have taken a clear lead in doing so. Therefore, the need to support open standards to encourage interoperability of emerging technical solutions is one of the grand challenges (Dearden *et al.*, 2010).

The advantages of Open Source Software (OSS) development model are already quite well understood and documented in empirical research (Ghosh, 2007, 2006; Feller et al., 2007; Ye and Kishida, 2003 cited by Malinen *et al.*, 2011). OSS gives users the freedom to run, modify and redistribute copies of either the original or modified program. However, the mobile industry is dominated by proprietary technologies and this situation is mirrored throughout academia. The emergence of “app stores” model provide a platform where small applications are exchanged for small amounts of money without any requirement to share code and there are growing evidences of apps developers using open source components to speed development of applications. A recent study found around 70% of (Android and iPhone) mobile apps containing open source code fail to comply with their respective licenses obligations such as making source code available and providing a copy of the license (Samson, 2011). The popular Apple apps store restricts usage and imposes further limitation on usage rights that were envisioned by the original licensor of the open source code (Rodrigues, 2011). Similarly, Windows Microsoft licenses bans products containing open source code (Halfacree, 2011). Therefore, an apps store approach to mobile application development is restrictive as it discourages the use of open standards.

2.9 Open-source hardware

Even though OSS development has received increasing scholarly attention, the research on open-source hardware (OSH) is still in its early stages (Malinen *et al.*, 2010). The open-source hardware supports creativity by offering flexibility in both design and function without being constrained to the system created by the maker (Mellis and Buechley, 2011), whereas a locked down device restricts creative and innovative development (Moore *et al.*, 2009). There are several established OSH projects[9] providing opportunities for the community to directly influence the hardware roadmap of a device and thus generate possibilities for creating new and sustainable solutions within specific markets. For example, the Robotic Open Platform[10] is an open source system for robot hardware designed to serve as a library that robot developers can use to add their designs or improve existing robots, allowing the community to build the robot at a relatively low cost.

Open-source copyleft platforms documented and published under an open hardware license are relatively new and have a promising future. They are developed from the participation and collaboration within a community that strongly believes in preserving the 'freedom' by copyrighting the free access to mechanical & electrical design documentation. It allows modifying & fixing faults easier and more effectively. Use of such platforms that can support creativity and provide freedom and unlimited choices for developers

[9]OSH Projects http://p2pfoundation.net/Product_Hacking
[10]Robotic Open Platform http://www.roboticopenplatform.org

and end-users may allow development of cost-effective hardware and software solutions, which will ultimately empower end-users with wider possibilities.

Copyleft license guarantees every user has freedom and anyone who redistributes the software and hardware design, with or without changes, must pass along the freedom to further copy and change it. It allows everybody to use that work for free, without paying royalties, licensing fees, etc. as long as certain constraints are followed. According to GNU:

…to copyleft a program, we first state that it is copyrighted; then we add distribution terms, which are a legal instrument that gives everyone the rights to use, modify, and redistribute the program's code, or any program derived from it, but only if the distribution terms are unchanged. Thus, the code and the freedoms become legally inseparable. The "left" in "copyleft" is not a reference to the verb "to leave"—only to the direction which is the inverse of "right".

As the restricted license of a proprietary devices do not allow using hardware designs freely, the copyleft approach however ensures the design is always open for a complete customization, enhancement or extension, allowing the community to influence its future hardware revisions and there is no end of life for devices as in a proprietary system.

If copyleft approach used, even if the device fails, it can at least ensure that the design can continue to live and be improved in future. But, as Weiss (2008, p.33) highlighted, "as it has happened with open source software, though, it may take some years and test cases for legal clarity to emerge in open source hardware". Therefore, while benefits of an open-source software are well established, hardware based on an open-source copyleft designs to support specific need such as supporting education are yet to be seen. Also, Weiss (Weiss, 2008) raised several challenging questions that open source hardware faces such as how would business benefit from open sourcing hardware and who is really going to make their own device?

Figure 8: The FreeRunner: Linux-based Mobile Phone

At the moment, there are limited numbers of such copyleft hardware available. A Linux-based mobile platform Openmoko[11] is a project to create mobile phones with an open software stack. They have so far released the 'Neo 1973' and more recently the 'Neo FreeRunner' (see Figure 8), for which hardware components were selected based on the requirement of publicly available documentation. There are more than twenty different distributions that can be installed on these mobile phones, which give end users the option to choose the one that suits their needs. But, despite this choice, the user experience on these phones is still poor. According to Weiss (2008) using these devices is much appreciated by those with the knowledge of Linux OS running inside these phones. However, even though it is not the powerful hardware available, it highlights the possibilities and benefits of

[11] Openmoko http://wiki.openmoko.org/

allowing users and developers to transform mobile hardware platforms into unique products to fit the purpose.

The sub US$100 WikiReader (see Figure 9), also by Openmoko, offers an interesting alternative to the phone. The Wikireader is a non-wired mobile device. The Wikireader software platform is open source and freely available. The software is loaded directly from the micro-SD card that stores the content as well. This US$99 handheld device stores the text enabling an offline access and an interface has been designed aiming to provide a simple navigation model.

Initially, it provides the content of Wikipedia (an electronic encyclopaedia), which can now be updated to display in fifteen different languages. It allows the software developer to customize or adapt the software and contents as necessary. Most importantly, as these kinds of devices are very limited in functionalities, they may have minimal resale potential. In Nepal's context, this can be seen positive since they would be more likely to be used for learning purposes rather than being stolen or sold. Therefore, "One trick pony" devices can be a safe solution (Camara *et al.*, 2010). Also, for the rural communities with limited ICT experience, a few interaction points on a device can reduce the time it takes for users to familiarize themselves with the device. But most importantly, this may reduce uncertainty.

The Wikireader device has a reflective monochrome display, a scratch resistant tempered glass screen and strong plastic casing for added durability. It runs on two AAA batteries for 12 months in normal usage.

Sustaining such cost should not be a hindrance compared to getting to and paying for Internet cafes.

Another promising sub US$100 open copyleft hardware device is the Nanonote (see Figure 10) by Qi Hardware – an ultra-small form factor computing device with 3.0” colour TFT display. It has a clamshell design with a QWERTY keyboard but it is designed for thumb-typing. The device is still in its infancy and does not have a built-in wireless capability.

Figure 9: Wikireader – offline handheld reading device

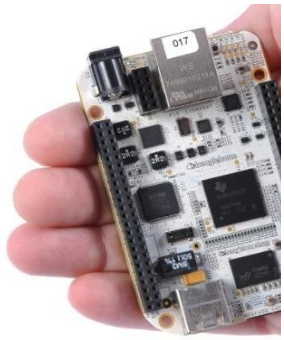
Figure 10: Ben Nanonote - an ultra-small form factor copyleft computing device which has 336 MHz XBurst CPU, 3.0” display and 2GB NAND flash memory

Arduino (see Figure 11) is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and the template-based coding systems which is commonly used to study the hardware to understand how it works, make changes to it, and share those changes. Open device BeagleBone and Raspberry Pi (see Figure 12) that support open-source software provide further learning possibilities with full-featured developer-friendly Linux OS. These devices do not have a case, and do not implement a local keyboard allowing complete access to hardware needed for programming applications such as controlling a robot.

However, open-source hardware projects have been less influential and successful than their open-source software counterparts as it may need a complex or expensive software tool to design and may encounter difficulties in separating design and construction (Mellis and Buechley, 2011). It also faces several challenging questions such as whether the open-source software model is transferable into physical production or not, how would business benefit from open sourcing hardware and who is really going to make their own device? (Weiss, 2008; Malinen *et al.*, 2010).

Figure 11: Examples of copyleft hardware (Arduino: electronics prototyping platform and BUG Platform: prototype & produce wireless devices)

In the educational contexts, even though all of these devices were not designed specifically to be used for teaching and learning purposes, copyleft approach provides freedom to design and develop the device and the content as necessary. As Carly *et al.* (2013, p.8) refers to a work by Silver (2012) to highlight how education can also dictate hardware design choices. “In Russia, the E-OK tablet computer has two screens: one for reading and one for writing. This configuration, and the technology that underlies it, was developed specifically to accommodate educational tasks.” Therefore, open-source hardware can provide flexibility to accommodate the expected support for changing pedagogy.



Raspberry Pi	BeagleBone
• An ARM GNU/Linux box. • A credit-card sized computer. • Model A: 256Mb RAM, one USB port (£24.87) • Model B: 256Mb RAM, 2 USB port and an Ethernet port. (£31.86)	• A single cable development environment. • Bare bones hardware with access to interface signals for sensors and controls. • Runs full-featured Linux, including native scripting and compilation tools. • For hobbyists, developers and engineers. • (£56.17)

Figure 12: Raspberry Pi and BeagleBone

Compared to devices such as Arduino, BeagleBone and Raspberry Pi, Nanonote comes with a case, local keyboard and the 3.0" colour TFT display. Therefore, it can be used to develop any kind of application and also has the added benefit for users to use it while on the move. Currently, the device is not designed to be mass marketed consumer electronic product and at the moment, it is targeted at developers, so that it can be turned into something useful as necessary such as a media player or a gaming device or a learning device. It allows the software developer to customize or adapt the software and contents as necessary and it also offers an interesting alternative to the phone for supporting mobile learning. The difficult challenge is however to provide a service that users really need. Successful solutions also need understanding of the contexts, local culture, local practice and political issues. A clear understanding of the motivations and circumstances surrounding mobile device use and adoption from the perspective of the users themselves is critical (Sarker and Wells, 2003). Thus, there is a need to assess both the possibilities and constraints of such devices as learning tools.

2.10 Offline mobile learning

This research mainly focuses on offline approach to mobile learning. In developing regions, even though the number of overall web users is growing, a significant number of people still do not have regular, effective access and ability to use digital technologies (Boyera, 2008). Without an understanding of how the mobile internet is used in resource-constrained environments in the developing world, it will remain difficult to identify its impacts or how to best promote its utility (Donner and Gitau, 2009). However, understanding of technical characteristics of mobile learning helps to adopt the appropriate models of teaching and learning and the activities that it can support.

The implementations of mobile learning systems vary based on the types of devices, wireless communication technologies, delivery options, development languages and software platforms used. The types of information (learning materials, administrative information) used, e-Learning specifications and standards supported, location (on-Campus, off-Campus) and type of communication (Synchronous, Asynchronous) between students and teachers used also influence the design (Georgieva et al., 2005). Technically, mobile learning experiences are also based on the characteristics such as latency, waiting associated with a particular service; mobile learning usability and mobile learning connectivity that varies from ‘always-on’ to ‘haven’t got any’ (Traxler, 2005). Based on the connectivity, the existing mobile learning systems can be classified as follows (Georgieva et al., 2005; Fu and Ding, 2008):

‘Permanently online’ that requires permanent communication between the system and users’ mobile devices. ‘Offline’ systems are based on the learning material uploaded in the users’ mobile device and can be accessed without the need of wireless communication. ‘Frequently online’ systems are both on-line and off-line. While some part of the content is preloaded, it will also require wireless access between the system and the device. These approaches have their own advantages and disadvantages (Qian and Nan, 2008).

According to Qian and Nan (2008) applications of permanently online mobile education rely on the wireless network, and to most learners permanently online is hard to achieve and not necessary. Beyond the usage of voice communication and SMS, the stable and widely available low-end cheap phones might be able to manage an access and distribution of small pieces of information but are not capable of supporting interactive learning applications. It may also be costly if users are required to make repeat network calls from a basic phone (Schmidt *et al.*, 2011) to complete a teaching and learning task.

According to Jalil et al., (2015) pedagogically sound design for mobile learning application development is a key factor for providing a pleasant and rich learning experience in a mobile environment. The authors highlighted there are several challenges that need to be considered such as ethical, security and infrastructure issues in order to implement mobile learning at a scale, beyond pilots and content-centric approaches. Some lecturers can see Texting and surfing the internet in the classroom as disruptive. The students also can cheat during exams if they can access information at that time.

Even though applications based on smart mobile devices may prove to be highly successful, they are still either unaffordable or widely unavailable or of limited use in certain contexts such as when it may rely on availability of internet connectivity to function fully. They also suggested offline mobile learning with no interaction with servers is also not acceptable. But, one of the important challenges of broad areas for mobile computing is building applications that deal with the arbitrary disconnected nature of mobility, i.e. offline (Yang, 2000). As building networks and applications that can deal with intermittent services will be important (Dearden *et al.*, 2010), offline mobile education may have broad application scope in the context of developing country, as it can minimize the complexities of providing mobile learning by not having to deal with networking issues, malleability of design and content, simplicity and no steep learning curve. Offline access is a reliable and practical method of accessing learning resources due to lack of Internet, infrastructure and where available, because of a slower speed and expensive subscriptions.

2.11 The knowledge gaps

Though it is clear that mobile provides learning opportunities, ICT4D presents challenges to design a sustainable mobile learning solution and there is a limited understanding of interrelationships between mobile learning and ICT4D (see Figure 13). The selection and usability of devices, availability of connectivity, context of learning environment, pedagogy and mobile learning achievements are all dependent on the available infrastructure, digital content and services, and ICT capacity of teachers and students. However, there is still a need to address the actual interplay which has been insufficiently addressed in previous literatures.

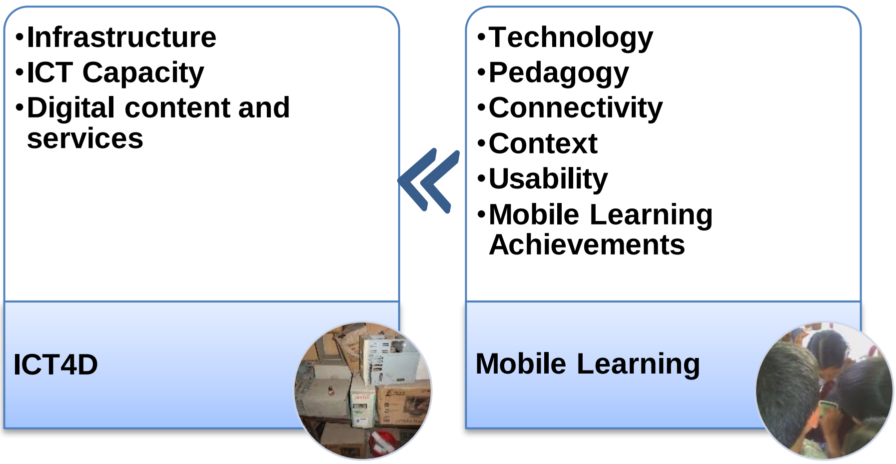


Figure 13: Mobile learning and ICT4D dependency (Source: Author)

From the comprehensive review of mobile learning and ICT4D, four main aspects are recognised and require consideration. They are ‘Mobile Devices’, ‘Teachers’, ‘Digital learning resources’ and ‘Schools learning environment’. This review will guide the data collection process and also provide a heuristic frame of reference to code the data into themes. Through the iterative process of data analysis and interpretation, this research will recommend a sustainable mobile learning solution approach in a context of a developing country. Such an understanding could provide a basis for finding ways to sustain a technology enhanced learning solution.

Therefore, to investigate the challenges to blend the use of mobile devices in a traditional classroom teaching and increase the students' class interactivity, this study will evaluate a specific technological innovation (open-source devices) in the formalised traditional teaching setting of schools in Nepal to support teaching English within a well-defined curriculum of class 9 and 10. The devices will be used to provide an offline access to relevant learning resources (content based application) and are expected to facilitate teaching that takes place in a behaviourist one-to-many manner in a classroom environment to more communicative approach of language learning. The direct users of the devices will be the teachers who are responsible for teaching English subject and are expected to play a central role to facilitate teaching and learning. It will demonstrate technical feasibility and pedagogic possibility in a context that presents environmental and infrastructural challenges to deliver and support education with conventional e-Learning technologies (Traxler, 2007). Hence, it will present a locally relevant sustainable mobile learning solution which is an outcome based on the realities and limitations of existing education, ICT infrastructure and the social and cultural context.

2.12 Conclusion

This chapter reviewed mobile learning in the broad context developed and developing countries. Most of the recent mobile learning researches have examined the use of the smart devices in a wide range of learning settings and presented the positive outcome. In developing countries, the challenges to deliver and support education with ICT are far more complex. Therefore, to explore the potential of mobile devices for teaching and learning in Nepal requires a different approach. This chapter analysed literature to inform and highlight the suitability of adopting the offline approach to mobile learning. However, in the context of Nepal, the core challenges of designing sustainable mobile learning solutions remain unknown at this point.

This review included a discussion of the concepts of open-source in software and hardware and examples of some of the open devices currently available. Open devices can be an alternative to locked-down solutions that can make small market niches commercially viable. But, even though open technologies might provide the tools developers' need to revolutionize the mobile industry, which can have considerable economic and social impacts on the further design and development of technology and its uses in various contexts, so far, its potential and associated risks remain unexplored for supporting education. Thus, the study presented in this thesis aim to examine both the benefits and limitation of open devices (Nanonote and Wikireader) by taking account of the need to understand the existing teaching and learning practices, and design solution based on the distinct understandings of a local context, to fully incorporate technology in the existing educational process.

The next chapter discusses the challenges of doing a mobile HCI research in a ICT4D context, an overall research approach and ethical considerations of the research.

Chapter 3

Research methodology

This chapter introduces the preliminary studies that will be conducted for this research to identify the mobile learning challenges and explore the use of Wikireader and Nanonote devices to support mobile learning. It describes the overall research approach, the procedures and methods to collect and analyse the data emerging from the evaluation. To remind once again, the aim of this research is to identify the challenges of designing a sustainable mobile learning solution. It includes a developmental study and a main study including three sub-studies as part of this research. The developmental study will evaluate the usability of these devices and possibility of using offline approach to mobile learning. The study in Nepal will identify the benefits and difficulties of introducing technology for supporting schools' education. An exploratory study will evaluate the use of these devices to support teaching English and highlight the further challenges of designing a sustainable mobile learning.

3.1 Challenges of doing research in Mobile HCI/ICT4D

Ubiquitous computing is rapidly expanding and the good understanding of the dynamic nature of existing and upcoming mobile technologies is needed to identify its potential role (Bodker and Buur, 2002). "Mobile technologies facilitate the generation of new knowledge, and challenge the notion of education as a modernist meta-narrative and deliver knowledge and information in ways that challenge formal learning" (Vavoula *et al.*, 2009, p.159). Therefore, the ubiquitous and pervasive nature of contexts or settings in which mobile learning takes place makes it difficult to evaluate and assess its impact.

To adapt a technology to the users need and vice versa (Deegan and Rothwell, 2010) and embedding the solution in real learning scenarios and sustaining and scaling for the future are challenges for mobile learning (Traxler, 2011b). Thus, to successfully develop mobile learning applications, integrate and use it in the education, it is important to understand the technology and adapt pedagogy in the varying context of use.

There are sophisticated mobile learning theoretical models that help to identify the sets of characteristics and relationships which establish the core features of mobile learning (Kearney *et al.*, 2012). But, mobile HCI research has changed methodologically as highlighted by Kjeldskov and Paay (2012, p.1):

“From being almost exclusively driven by engineering and applied research, current mobile HCI is primarily empirically driven, involves a high number of field studies, and focus on evaluating and understanding, as well as engineering. It has also become increasingly multi-methodological, combining and diversifying methods from different disciplines. At the same time, new opportunities and challenges have emerged”.

In the recent literature review Islam and Grönlund, (2016) highlighted the lack of robust evaluations of ICT programs due to lack of research rigor. As the paper describes, much research is self-reported that overlook potentially unpleasant realities on the ground due to lack in rigor as concerns focus and methods for collecting data, and indeed in the size of the tests.

The review also find that the overwhelming share of the evaluation literature is from developed countries, and mostly from the USA.

There are methodological challenges to effectively understand the use of mobile devices and applications in the context of developing countries (Hagen *et al.*, 2005b) as literature review shows the lack of a specific mobile learning model for teaching and learning in a developing country's context. There also lack the research studies in developing regions that investigated mobile learning within a theoretical framework to explore the process of learning which is important to deepen the understanding of students and teachers' experiences of using a mobile learning solution. "Due to the specific cultural, infrastructural and governmental context, applying Mobile HCI research method unchanged is likely to fail" (Dörflinger and Gross, 2010, p.1). Therefore, Vavoula *et al.*(2009) highlighted that the "western" research approaches and methods are not always relevant and appropriate when studying mobile learning in other parts of the world. Thus, this research study aims to develop the valuable insight from a socio-cultural perspective.

3.2 Research approach

This research takes an epistemological perspective of constructivism (see Figure 14) which acknowledge that the truth and meaning do not exist in some external world, but are created by the subject's interactions with the world. Hence, meaning is constructed not discovered and a theoretical perspective linked to constructivism is interpretivism (Gray 2004).

Vavoula et al. (2009) presented the view of (Van‟t Hooft 2009) that while designing mobile learning, it is necessary to take a closer look at process rather than product of learning. This study seeks to identify the overall challenges of supporting teaching and learning, benefits and drawbacks of the methods of a mobile learning and technology used, by interpreting the response of teachers that engage with the learning and its overall impact on changing learning process. Researchers have recognized that there is also a need to consider the social, cultural, and economic issues, as well as the technical issue, to understand a sociotechnical phenomenon, such as ICT4D (Thapa, 2012). Therefore, this research is based on an interpretivist paradigm which can contribute to our deeper understanding of rich contextual information.

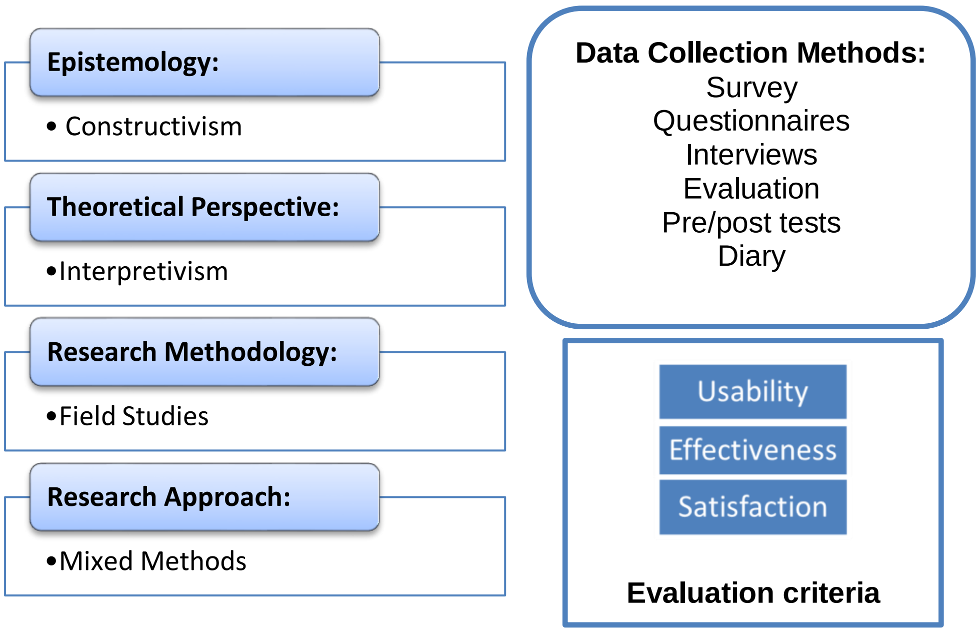


Figure 14: Research Design

Based on the classification in terms of research method and purpose (see Table 2) (Kjeldskov and Paay, 2012), the **purpose** of this exploratory research study is to **understand** the core challenges of designing a sustainable mobile learning solution by **evaluating** the mobile device usability (hardware/software characteristics) and user requirements in a local context of a developing country. Due to exploratory nature of this research, the research methods used for this research are grounded within the methodological approaches of **field studies** which presents "numerous opportunities for exploring rich real-world use cases, contexts and user needs to gain deeper understanding" (Kjeldskov and Paay, 2012).

Table 2: Overview of research methods and purposes (Kjeldskov and Paay, 2012)

Method	**Case studies**	Intensive empirical investigations of contemporary phenomena within small size entities such as groups, organizations, individuals, systems or tools in real-life context with the researcher distinct from the phenomena being studied
	Field studies	Characterized by taking place in "the real world" covering a range of qualitative and quantitative approaches from ethnographic studies of phenomena in their social and cultural context to field experiments in which a number of independent variables are manipulated
	Action research	A method through which researchers not only add to the body of scientific knowledge but also apply that knowledge to the object of interest through intervention and participation in the activity being studied
	Lab experiments	Characterized by taking place in a controlled environment created for the purpose of research or in dedicated laboratories allowing a detailed focus on specific phenomena of interest with a large degree of experimental control
	Survey research	Informs research gathers large amounts of data through various techniques such as questionnaires and interviews from a known sample of selected respondents assumed to be independent of their environment
	Applied research	Builds on trial and error on the basis of reasoning through intuition, experience, deduction and induction. Typically the desired outcome of an applied research process is known while means of accomplishing it is not. This makes applied research very goal oriented.
	Basic research	Characterized by trial and error based development of new theories and the study of well-known problems to which neither solutions nor methods are known, relying on the competences of the researcher
	Normative writings	Cover the body of "non-research" writings about phenomena of interests such as concept development writings organizing ideas for stimulating future research, presentation of truth describing ideas that seem intuitively correct, and descriptions of applications.
Purpose	**Understanding**	The purpose of research focusing on finding the meaning of studied phenomena through, for example, frameworks or theories developed from collected data.
	Engineering	The purpose of research focused towards developing new systems or parts of systems, for example an interaction technique for a mobile device, or a mobile application or device.
	Re-engineering	The purpose of research focusing on improving existing systems by redeveloping them such as, for example, adapting a web browser to a small display.
	Evaluating	The purpose of research assessing or validating products, theories or methods, for example, the usability or user experience of a specific application, or a theory of interaction.
	Describing	The purpose of research focusing on defining desirable properties of products, for example, a mobile guide system, or mobile HCI method.

It takes the bottom-up approach with an emphasis on identifying the needs before developing a solution as the reverse top-down approach based on assumptions is not recommended in ICT4D domain and there is no one size fits for all solution (Toyama and Dias, 2008). Carly *et al.* (2013, p.22) suggests "avoiding the top-down imposition of unsustainable technologies by well-intentioned researchers and NGOs outside of clearly framed and highly targeted trials". Regardless of increasing number and variety of pilots and trials involving mobile learning, many technology-led projects fail to scale and sustain. Therefore, impact of a top-down externally designed initiative such as the OLPC project is very limited.

The FRAME model as discussed in chapter 2 (2.1) could be used to develop a mobile learning solution or evaluate the potential and suitability of a mobile device for distance learning. But all the aspects and intersections of the framework may not be directly applicable and lacks consideration for wider aspects that make such solution sustainable in a specific context of a developing country.

This research includes a developmental and a main study, which further includes 3 sub-studies (see Figure 15). Developing appropriate methods for mobile learning research does not necessarily mean having to develop an entirely new suite of methods of data collection and analysis but instead it is recommended to build on, and refine existing good practice in order to identify methods that are fit for purpose and adhere to established attributes (Pachler 2009).

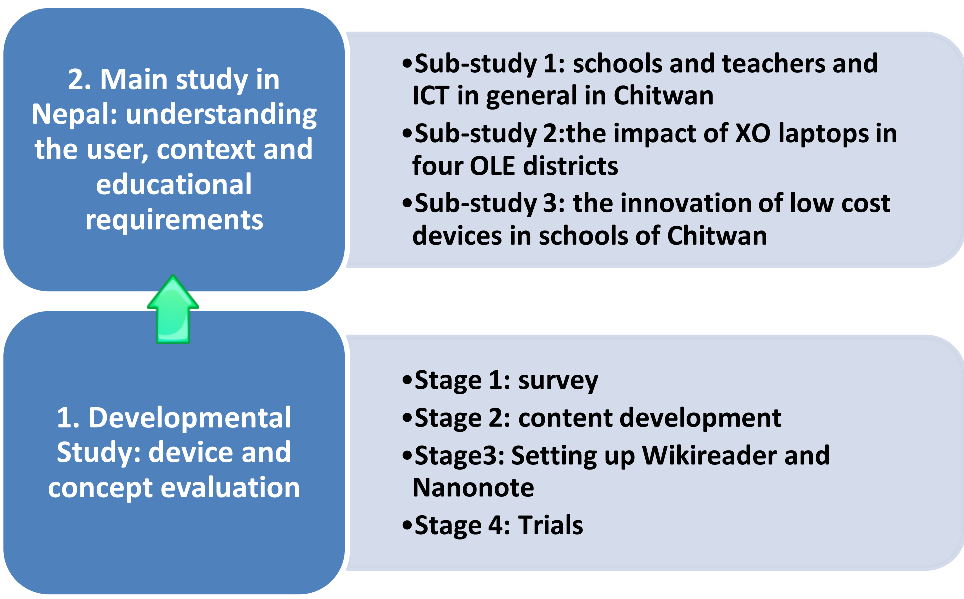


Figure 15: Bottom-up research approach

From the fields of Mobile Human Computer Interaction and Mobile Design research (M-HCI/D), this research takes Mixed-methods approach and will employ research methodologies to gather and analyse quantitative and qualitative data. Selection of methods focuses on two main parts of the research. i) Understanding the context of the study and ii) the evaluation of an offline mobile learning solution. It primarily involves interviews, questionnaires, observations and supplemented by other data collection method, such as note-taking or tape-recording during interviews, to capture teachers' and students' interpretations effectively. The post-test questionnaires for the evaluation of previously unexplored Wikireader and Nanonote devices will adapt the earlier studies of adoption of mobile technology for learning (Corlett et al., 2005; Waycott, 2004; Koole, 2009), which mainly aims to address usability (will it work?), effectiveness (is it enhancing learning?) and satisfaction (is it liked?) (Sharples 2009). Data analysis will be a process of reflection on users' experience of teaching and learning and using the technology.

3.3 Ethical considerations of the research

As a prospective research student, I was required to complete the Postgraduate Certificate in Research prior to enrolling as a research student. Following the period of initial enrolment, the proposal for registration was submitted to the University of West London. In the process of approving the proposal, the University Research Degrees Sub-Committee, on behalf of the Academic Board made sure the ethical considerations have been addressed.

This research strictly adheres to the UWL Research Ethics - code of practice 2009/10, Code of Practice for research within the Faculty of Professional Studies and Statement of Ethical Practice for the British Sociological Association (March 2002) to make sure research studies is being conducted ethically. As the developmental study will involve the students at the University of West London, ethical approval will be obtained from the faculty research scrutiny and ethics committee. With the form, copies of participant information sheets, consent forms, questionnaires to be used will be submitted (see Appendix J, K, L).

Dearden and Tucker, (2015) highlighted the ethical limitations of conducting research in ICT4D environment which remain a geographically distributed activity that is likely to include some occasions where researchers make short-term visits to places and communities. To avoid such unethical bungee jumping to be the primary mode of interaction in my project, I will follow the Mobile HCI/ICT4D guidelines.

As literature in ICT4D research recommends, to avoid running into conflicts even before starting the research, the understanding of challenges of carrying out a research in the field and the familiarisation of schools' environment in Nepal is vital. It will help tackle possible serious ethical questions that may be raised, identify willing/genuinely interested participants and build the much-needed co-operation. Later, schools will be formally contacted and informed about the research study to obtain the consent.

"Furthermore when research is led by people who are not familiar with a social and cultural setting, and may not even speak the local language, the reliability of research data and decisions based on the data should be questioned" (Dearden and Tucker, 2015). In my case, although I am originally from Nepal and well informed about the contextual setup, my role is that of an outside observer avoiding personal influence into the interpretations of the subject and outcomes. While conducting research, the participants will be made aware of their rights to confidentially and privacy through the use of informed consent, through explanations of the research, guarantees of anonymity in the thesis. The participants' decision will be respected and possible reluctance or refusals in interviews will be accepted without any objections. Participants will be assured that the purpose of this study is to investigate the challenges of designing a sustainable mobile learning solution and is not their own assessment. A full information sheet will be given to outline these assurances (Appendix F). I will also provide my contact information. Participants will not be paid or rewarded for taking part in the research but support from non-profit organisations and other interested individuals will be sought to setup an offline digital library in schools during the study.

Mobile learning solutions are generally built with the assumption that learners have access to data networks. In schools of Nepal, use of Internet for the educational purposes is rare and some of the teachers have negative perceptions toward the use of the Internet and especially social networking sites. Nepal government also ban use of mobile phones in schools, as it believed to affect students' performance. Therefore, this research study approach supporting education 'offline' with completely unconnected mobile devices with no communication facility.

3.4 Developmental study: device and concept evaluation

The aim of this study is to evaluate open-source platforms and find out if these open-source devices have potential to facilitate an offline mobile learning. In this study, the delivery of course materials will be piloted using WikiReaders and Nanonotes, providing offline access to content from a course module. The success of the study will be evaluated by assessing students' experiences. This pilot study will help determine the feasibility of using Wikireader and Nanonote devices for teaching and learning and to learn the lessons for possibly design a main study in Nepal at a later stage.

3.5 Main study in Nepal: understanding the user, context and educational requirements

This research study will focus on investigating the possibility of using mobile platforms to provide resources to support teaching and learning English subject, which is a part of Nepal's public school's curriculum. Initially, due to limited understanding of users and culture, it is not possible to be certain about the actual value of the technology and how it may be used in that context (Reitmaier *et al.*, 2010). Therefore, before thinking about trying to change or improve pedagogy of learning using mobile devices, the aim is to identify the best approach to mobile learning using an open-source technology to provide the much-needed digital access to resources for English teachers in schools of Nepal.

The objectives of this study is to identify the opportunities and the challenges to introduce a simple and sustainable offline mobile learning solution possibly using a low-cost open source mobile technology that might be affordable and flexible. It will include 3 sub-studies.

The aim is to identify) the current challenges in public schools that lack access to ICT, b) investigate how ICT might be helping public schools in teaching and learning and identify further challenges and finally c) explore the opportunities to supplement the existing teaching and learning practices by providing a much needed access to digital resources using low-cost open-source mobile platforms.

3.6 Conclusion

This chapter has described the research approach, planned studies, the stages and methods to be used. To create a mobile learning environment to support learning is a huge challenge. The main benefit of this research will be identifying the challenges to sustain a mobile learning approach. As the research aims to explore a new technology, an unconnected Wikireader device with a single functionality and a pocket size Linux computer Nanonote, it is not possible to predict in advance how the students/teachers may use or even if they would adopt them at all. Therefore, the study is open to unexpected findings. The evaluation approach will not reflect what or how the users will be learning. However, due to lack of other resources in the context of rural school in Nepal, it may be possible to see the clear benefit of use and deduce learning gains due to these devices.

Chapter 4

UK developmental study: evaluation of Wikireader & Nanonote devices

This chapter reports on a study of students' exploration and use of low-cost open-source mobile devices for learning. The study was carried out between May 2010 and February 2011. A journal paper has been published ("Evaluation of a hands-on approach to learning mobile and embedded programming", Appendix M), and has been cited twice according to Google Scholar. The question for which this user study aims to explore relate to the original research questions found in the introduction of this thesis. The question which is to be investigated in this study as defined below:

What are the benefits and difficulties of using open-source devices for teaching and learning? Conduct a developmental study to understand and evaluate the usefulness of the open-source devices to provide an access to the necessary resources and to support learning.

4.1 Introduction

Learning programming is not easy and there is no shortcut in learning to program (Hassinen and Mäyrä, 2006;Sheard *et al.*, 2009). Generally, the learning approach is based around lectures on specific topics, followed by tutorial / practical sessions on applying the lecture content to specific case studies. "Programming language concepts are highly logical and therefore difficult to understand by conventional study materials" (Patil and Sawant, 2010). Even though the traditional approach of concepts first is common, students struggle to learn program due to lack of extensive hands-on practice and sufficient time to become familiar with programming concept (Ala-Mutka, 2004). Therefore, a clearer approach to teaching programming is needed (Milne and Rowe, 2002) and research has shown a learner-centred approach to teaching programming is effective and successful (Moura, 2011).

In this exploratory developmental study, the focus is on the sub US$100 open-source handheld mobile devices. As the cost of hardware reduces we are beginning to reach a point where it will become possible to replace a USB flash storage device in your pocket with a small computer. This style of ubiquitous computing provides some interesting learning opportunities but also poses significant technical and usability challenges.

This chapter reports on an empirical study of the deployment of Nanonote and Wikireader for learning programming with the group of twelve students studying MSc Mobile and Networking. The aim was to evaluate the usefulness of devices in teaching and learning by assessing its usability, probing how students used such devices and identifying problems while learning programming and provide support throughout the study period. The findings indicate these open-source devices have potential to facilitate offline mobile learning and enhance motivation to learn programming without being restricted to the limited practical sessions in the university lab.

4.2 Open-source platforms and educational contexts

"Open source software offers great opportunities to bring real-life experience directly into the classroom and in particular, it can be used to emphasize the importance of high quality software design, the role of design patterns, the need of good documentation, and the relevance of social skills in a real-world environment" (Pedroni*et al.*, 2007, p.1). "The free and open-source software (FOSS) culture, principles, and practices are very much suitable for a student-centered educational environment that is inquiry-based, highly collaborative, motivational and relevant, and inclusive of diverse abilities, cultural backgrounds, and life experiences" (Jacobs *et al.*, 2011, p.42).

Open-source hardware platforms can also be used in the context of teaching and learning programming. Simple and affordable devices can greatly improve the interest in the subject and allowing students to try their skills on a real hardware can make it easier to concentrate on the programming problems. It makes the lessons much more attractive for students and also their results are better compared to lessons where only simulators and/or computer models are used (Dolinay*et al.*, 2011). But the transforming of teaching to create effective learning environments has many challenges related to types and scope of projects students get involved with; infrastructure resources and expertise needed to carry out these projects; learning outcomes and assessment measures; and limitations and barriers experienced with various teaching approaches (Jacobs *et al.*, 2011).

However, as the access to open-source technology is improving, a well-designed open-source oriented course utilizing open-source software and hardware platforms can help to create a learning space (deBry, 2011), a space where students feel supported & respected, a space that is open to conversation by its nature, a space for developing expertise by challenging to write good code and a space where students are motivated to take ownership for their software and hardware and encourage to experiment with the complete freedom and practice what they learn.

4.3 Learning programming using mobile devices

"Mobile application development requires a considerably different approach compared to applications for the desktop computers and need the understanding of the complexity of their operating environment, which is much less predictable than contemporary fixed wire networks, and the restrictions placed by the devices themselves in terms of memory, power, speed, screen size, etc." (Edwards and Coulton, 2007, p.310). Therefore, it is important to encourage students to gain practical skills to develop applications with the understanding of the existing limitations of the mobile platforms that a developer faces daily. Introducing mobile devices at an early stage in the computer science curriculum can improve students' learning (Mahmoud and Popowicz, 2010) as a use of hands-on oriented approach in introductory programming courses has shown increase in a positive experience (Kulkarni, 2010;Richards and Smith, 2010).

Bruhn and Burton (2003) studied the use of computers in the classroom to help students to better understand programming concepts during classroom presentations. Even though this approach helped the average-to-poor students' achievers the most, it needs more time to present the material to the students and it also takes time for students to practice programming concepts on the computer in class. Research shows that only through adequate practice and training can expertise be obtained in the field of programming (Bruhn and Burton, 2003;Ala-Mutka, 2004) and thus learning should go beyond classroom/lab environment.

Some of the proposed approaches to teaching computer programming are using robotics or through the use of game design and using mobile devices (Mahmoud and Popowicz, 2010). Introduction of mobile devices in programming education provides the practical development experience students need and students appreciate the unique opportunities mobile devices offer and also become aware of the development challenges they present (Mahmoud and Dyer, 2008; Mahmoud and Popowicz, 2010). However, the analysis of research papers about programming education published in computing education conferences identified only few studies that considered online distributed or mobile learning in programming education (Sheard*et al.*, 2009). Therefore, this research approached teaching programming by using mobile devices to provide relevant programming knowledge and these devices can also be used for hands-on practices. At the time of this review, researcher was not aware of research studies that explored open-source platforms particularly the Nanonotes and WikiReaders in such programming education context. Due to nature of the devices used, evaluating them in this learning context, it was expected that this study would be more rigorous and findings more accurate.

4.4 The Module: Mobile Application Development (MAD)

The developmental study was carried out in University of West London with a small group of twelve full-time students studying Mobile Application Development (MAD), a 20 credit module which is a part of the MSc Network and Mobile Computing course. This module has been developed to provide hands-on experience developing software for mobile devices using an open source approach to software development and students are expected to gain experience using relevant industry standard tools to support their work. It introduces the student to the difficulties associated with developing software on embedded devices and provides a background to embedded development. It enables the student to gain experience in different programming languages typically used for mobile and embedded development and provides the student with the foundation required to enable skills transfer to an industry equivalent situation.

The MAD module is delivered over the period of fourteen weeks and provides three hours of class contact per week. One hour for a formal lecture and two hours of practical lab classes. There are two parts in this module. First seven weeks focus on the use of C Programming language and in the other half; students use the higher-level programming language building on the experience from what they learned from the first seven weeks.

To pass this module, students are required to submit two assignments in seventh and the fourteenth week which is the end of the term. Both assignments have one element each which required developing a command-line application that is capable of communicating structured binary data across a TCP/IP network and suitable for deployment on a Linux based embedded device. As it is important to gain some experience designing and structuring binary network protocols, students are introduced to the Packedobjects - a data encoding tool that provides high-level bit-packing on low-level devices (Moore, 2010).

4.5 Study approach

The study was conducted over a period of fourteen weeks in four stages. This study took an action research approach. The basic premises of this paradigm are that the research is “participative, grounded in experience, and action-oriented” (Reason and Burgess, 2001 p. xxiv in Lunsford, 2010). The students’ participation helped not only to evaluate the devices but also to understand the problems they faced while learning programming and to provide the necessary support during the study. The study was supported by Institute for Teaching, Innovation and Learning (INSTIL) which provides support and leadership on all aspects of teaching and learning in University of West London. The goal was also to disseminate the findings within the University for the wider use of other staffs and students that could lead to possible changes in practice. Even though this study aimed at supporting teaching and learning programming in Higher Education, it mainly focused on better understanding the use of offline mobile technologies, and on the device usability.

As this research attempted to locate the distinctive features of learning with open-source platforms, it took the bottom-up approach to understand the user need, context of use and the feasibility of devices guided by a FRAME model (Koole, 2009). The model is discussed in chapter 2, section 2.3 (p.50). It helped to focus on the need to examine and understand the characteristics of learning environment, learners and their preferences from a socio-cultural theoretical orientation. To gather and analyse quantitative and qualitative data on mobile learning and usability, the developmental study employed mixed research methodology, which is also the most common approach used in programming education research (Sheard *et al.*, 2009). From the results of this evaluation, the aim was not to ascertain whether or not these devices can improve learning. Finally, the name of students and teachers have been anonymised in this study to protect the identity.

4.5.1 Stage 1: survey

At the beginning, the written informed consents were obtained from the students who agreed to participate in this study (Appendix J) and administrated the pre-questionnaires and analysed the demographics (Appendix C). The initial survey of the mobile usage of students was undertaken to establish the lack of high-end or ‘smart-phones’ and therefore justify the cost-effective device approach to mobile learning. In this survey, information about students’ choice of phone, payment plans, and mobile internet usage including their personal usage were collected.

Then students randomly selected the devices, so that the six students had WikiReaders and other six had Nanonotes (Appendix A). As prerequisite, the students were expected to be familiar with some programming and Linux desktop environment and where available, they were also encouraged to setup Linux system in their personal machines.

4.5.2 Stage 2: content development

Early preparation was required to make this study possible and it was necessary to create a delivery platform for student access to the course materials. The preparation started in the summer as the module was delivered in September 2010. It gave enough time to prepare and set-up the developmental study.

University of West London has taken out a licence for a Blackboard plug-in called Teams LX, part of Campus Pack from Learning Objects Inc. It allows staffs and students to create personal blogs and wikis within UWL Online. Initially, a plan was to setup a course wiki so that instructor can create and edit articles, but anyone can read those articles and leave comments.

4.5.3 Stage 3: setting up Wikireader and Nanonote

At this stage, the content from the course wiki was uploaded to the Wikireader device. It involved importing an XML dump from the wiki to be compiled and copied to micro-SD cards. The Nanonote devices were customised to support the necessary software to provide hands on experience of packing data and communicating it across different kinds of hardware. The devices were then loaded with necessary PDF manuals.

4.5.4 Stage 4: trials

At the beginning of this study, the first part of the module was taught using combination of lecture and practical class where students had hands-on experience of programming in the lab. But on the second part of the module, they were also given Nanonote and Wikireader devices to take away and use until the end of the term. The students were not trained specifically to use these devices, as they were expected to explore and use the devices to support learning programming. The organization of this study and the data collection was completed in four months.

As the students were studying other two modules as part of the MSc course and busy with assignments, the data collection techniques were simplified so that this study would not be felt as a burden to them instead of the goal of providing support for learning. Therefore, even though use of the diary study method was initially planned, students were requested to keep the log of their activities instead (Appendix B). Research shows that diary study method can suffer from the drawback of potentially missing data, because participants may forget to record entries or are selective in reporting (Bolger and Davis, 2003), and also possible that they may find it difficult to write unprompted (Hall, 2008). In the activity log, students simply recorded *'when? where? why?*' they used the devices and documented if they found them useful and also record the problems or difficulties they faced. The simple log provided an effective way to monitor progress and also identify learning issues early and provide appropriate support.

Post-test questionnaire (Appendix D and E) at the end of the study was used to find out what features of the device the students had used and whether they had found it to be a useful tool for supporting learning and what the benefits and limitations of the technologies were. The activity logs were also used in a supplementary manner which helped to further understand the students' view that they expressed in the post-test questionnaires.

4.6 Device aspect (D)

According to Kenny et al (Kenny *et al.*, 2009b) mobile learning is constrained by the mobile device hardware and software configurations and dependent upon adjustments in teaching and learning strategies. While benefit of mobile learning is clear, developing sustainable solution is still a challenge, as the mobile industry is dominated by proprietary technologies and this situation is mirrored throughout academia. Therefore, even though the use of the latest mobile technologies can have significant impact on teaching and learning, assessment of the technology platform for the long term is important to sustain the solutions.

Ownership of the technology is equally important in mobile learning (Corlett *et al.*, 2005;Traxler, 2010). But, mobile learning approach centred on student devices is challenging as well. “From a methodological perspective it is easier with a homogeneous technology platform and also easier from a staffing and infrastructure perspective but such solutions are unsustainable because they are predicated on finance in order to provide devices” (Traxler, 2010). From a developer's perspective, creating solutions for a locked-down device restricts creative and innovative development as well (Moore *et al.*, 2009).

The selection of the open-source mobile platforms (Nanonote and Wikireader) for this study was based on the requirement of this module which is to enhance students’ understanding of the limitations and constraints when writing software for embedded devices. The study needed mobile devices that were comparatively cheaper (sub US$100), freely customizable and portable that students could use anytime anywhere without incurring extra cost. The use of such cost-effective open-source platforms support creativity and provide freedom and unlimited choices for students. It is believed that the chosen platform may allow moving pilot to the mainstream of educational provision and finding secure and sustainable funding and support (Traxler and Leach, 2006).

4.6.1 Preparation of devices

The university has a Windows based network and there is no dedicated lab for Mobile and Networking students. However, in one of the university's lab, each computer was setup with a dual boot Ubuntu and Windows operating systems. In the existing system, university does not allow students to install necessary open-source software. Therefore, by introducing these open-source mobile devices, the hope was to relax such constrains and provide total freedom for students to practice programming in the university and also outside the institutional contexts.

Figure 16: Setting up Nanonotes and Wikireaders

The Nanonote devices were customised to support the necessary software to provide hands on experience of packing data and communicating it across different kinds of hardware. Setting up devices (see Figure 16) was a non-trivial task, but worked well after careful preparation. Due to the specialised nature of the module, students were also free to customise their devices, such as changing the default distribution and adding multimedia content. The device related and available software is well documented and freely available online.

The Nanonotes were configured with lightweight JlimeMuffinman Linux distribution which has been built using OpenEmbedded with Jlime look and feel. It included already configured several useful stripped-down versions of applications to supplement it and also a complete software repository. The current image provided an X Environment, Matchbox window and desktop manager, and several useful applications such as video player, music player, image viewer, text editor, terminal, PDF viewer, dictionary and games. The devices were then loaded with necessary PDF manuals.

The Wikireader devices were also customised to provide an access to necessary resources. Initially, the plan was to setup a course wiki based on the university's virtual learning environment (VLE), so that the lecturer can create and edit articles, but anyone can read those articles and leave comments. But, to customise the Wikireaders, the content from the course wiki to the device need to be loaded, which required importing an XML dump to be compiled and copied to micro-SD cards. Due to lack of flexibility of the existing VLE, a new Wiki site was setup using an open-source Mediawiki. The site was setup in such a way that only the lecturer could edit the pages. Then, Wikireaders were customised to provide an offline access to Packedobjects manual and also imported freely available Wikibooks, Wikiquotes, Wikidictionary and a full Wikipedia.

This study also highlighted that to take a full advantage of devices as such and to progress quickly, students must be supported in the early stages and their usefulness must be visible to them at the beginning. As the students are usually under pressure to complete assignments and prepare exams for different modules, they are unlikely to invest valuable time learning the devices so that they could possibly use for supporting the study. It is crucial to identify and provide the useful resources that students really need and align the use of the devices with the requirements of the module to enhance the learning experience by exploiting the potential added value these devices could bring.

4.7 Learner aspect (L)

Masters programmes attract overseas students, mainly from India. These students can have difficulties adapting to a UK university learning environment. Some of them also have limited access to ICT resources outside the university. Previously, course tutor also experienced students' inability to make a significant improvement in MAD module due to lack of programming skills and unfortunately many dropouts or change their course pathway where programming is not compulsory. While those who decide to do this module, many struggle as they often fail to recognize their own deficiencies.

In this study, all the students were male and were below 25, except for one student with age range 26 – 35. All the twelve students had regular access to desktop computer with Internet at home or university lab and library and good experience of using them for personal, work and study purposes. They also owned variety of mid-range to high-end mobile phones. 83% of students had post-paid (contract) phone but only 33% students had data usage plan. Most of the students were concerned about the cost of using mobile internet. Some of them did not need to use mobile phone for browsing as desktop use was sufficient for them and when available, some students preferred desktop computer to mobile device for accessing the internet.

Previously, none of the students had seen or used these relatively new Nanonote and Wikireader devices. However, they were enthusiastic and showed interest in participating in this developmental study as they thought it would be useful to have an access to resources offline to support their study and also use for hands-on experience.

With a diverse range of devices available which correspond with the mobile user's needs and budgets; creating a solution which works successfully for a range of different manufacturers and models would be difficult (Crane and Benachour, 2010). Also, even though the low-end phones are stable and widely available, they are not capable of supporting smart learning applications.

4.8 Device usability (DL)

While Wikireader is a dedicated offline text reading device, Nanonote is a general purpose Linux computer. This study is therefore not a comparison between these two different devices but instead their evaluation for the purpose of mobile learning. This study assessed how students used the devices, how easy and useful the devices were and the benefits and the problems they faced.

4.8.1 Wikireader

All the students said they used the Wikireader a few days a week to read and used it at home and while travelling as well. Out of 6, 5 of the students found it very useful for reading, while only 1 student found it somewhat useful. Most of the students found Wikireader easy to use. The most important advantage that students highlighted was the readily available content without using Internet in the portable, handheld and easy to use Wikireader device that supported uninterrupted reading at home or at work and also while travelling. As one of the student described the benefits: "*easy learning process, can be used anytime, anywhere, easy to carry in the pocket, no need of internet, low cost and very fast access to useful information*".

However, some of the concerns were the difficulty to search long phrases, sometimes not getting results as expected, having to go back to 'home' while navigating through the text, poor screen resolution, not knowing how to adjust backlight and not being able to read on nights. More than half of the students found onscreen keyboard neither easy nor difficult to use, while 2 students found somewhat difficult to type as they found touch screen unsmooth.

All the students found the 'Search' and the 'History' functions very useful and easy to use. But only 2 students found the 'Random' function useful, while 1 student found somewhat useful and 2 students never used this feature. Only 2 students used the device for reading other than the Packedobjects software manual. They found dictionary and quotes particularly useful.

While the one-function Wikireader was easier to use and read texts, none of the student attempted to update the device with their own content, even though they were encouraged to explore the open-source platform to appreciate its benefits to full potential. That's probably because there is no automatic synchronisation or straight forward updating mechanism for content. For newer content, the device software needs to be recompiled with XML dump and copied to the MicroSD card. Therefore, a further research is needed to develop a tool to facilitate this process so that a common user can also customise the device easily.

4.8.2 Nanonote

In this study, 4 of the students used the device a few days a week, while the other 2 students used only once a week. They used the device mostly at home and 2 students used while travelling as well.

Half of the students said reading on Nanonote was rather easy and the other students found somewhat difficult. They found reading PDF on the Nanonote was difficult due to small (3” size) screen and the difficulty to use the compact 59-key keyboard which had a considerable impact on the ease with which students could navigate through text. Even though students found thumb typing on the Keyboard convenient, they felt it was slow due to its layout and the small keyboard buttons and therefore said it needs more practice.

Even though some of the students found the Nanonote useful for reading PDF documents, they felt a steep learning curve to use the device and the software. In general, using the device required remembering functions of certain keys or combination keys and reading PDF documents specially required extensive scrolling both horizontally and vertically and also needed to remember different keys configured to start and close the application, zoom in and out while reading the document and to go to different pages.

However, beyond reading documents, one of the students also found Nanonote very useful for listening mp3 audio and watching videos while travelling. A student compressed the video using freely available software and copied to the device. While all the students appreciated the use of Nanonote to understand and learn the programming for embedded devices, only a couple of students attempted to flash the device with the minimal OpenWrt image containing GNU Guile built by the tutor and used for testing the command-line software they developed as part of the second assignment. As they had an unlimited access and control of this device, students were able to install and remove software, customise as necessary which they could not do in the lab computer. However, it is likely that prior instruction in their use will be needed as most of the students felt customising Nanonote will be somewhat tedious for the novice Linux users.

4.9 Analysis of activity logs

The Wikireader and Nanonote devices do not ship with any radio frequency (RF) communication capabilities therefore its applications fall under the category of offline mobile learning. Regardless of lack of Wireless connectivity, activity log shows 60% of the overall usage of the devices was at Home and 40% was while travelling. All the students said that they used Wikireader both at home and while travelling, but Nanonotes were used mostly at home.

They used both devices from few minutes to half an hour and up to maximum one hour. While using Wikireaders, all the students said that they sometime made notes on paper but only two users made notes on the paper while using the Nanonote.

The analysis of log shows, results of the 70% of the activities on Nanonote devices were useful, 10% of the results were somewhat useful and 20% of the results were not useful (see Figure 17). On Wikireader device, students found the results of the 77% of the activities useful, 9% of the results somewhat useful and only 14% of the results were not useful.

From the log, it was also possible to quantify the number of problems students encountered while using these devices and the result supported the views students expressed in the post-test questionnaire. It shows that students encountered 60% of the usability problems and 40% were the technical problems while using the Nanonote devices (see Figure 18). They faced technical problems such as difficulty in setting up DNS forwarding, difficulty in installing the tools needed on the desktop, which were solved with tutor's support in the lab. But it shows there were significant usability related issues especially the difficulties of using the software, the small keyboard and navigational issues while reading the content.

Wikireader users noted 28% of the technical problems related to typing especially long phrases in the touch-screen and 72% of usability issues were related to adjusting backlight and sleep mode and navigating using back button. Some of the activities were also related to searching for information unrelated to the course and students found unsatisfactory or limited results.

Portability: Even though these devices are small enough to fit into pocket and easy to keep it safe and secure physically, one of the students lost the Nanonote in the last week of the developmental study.

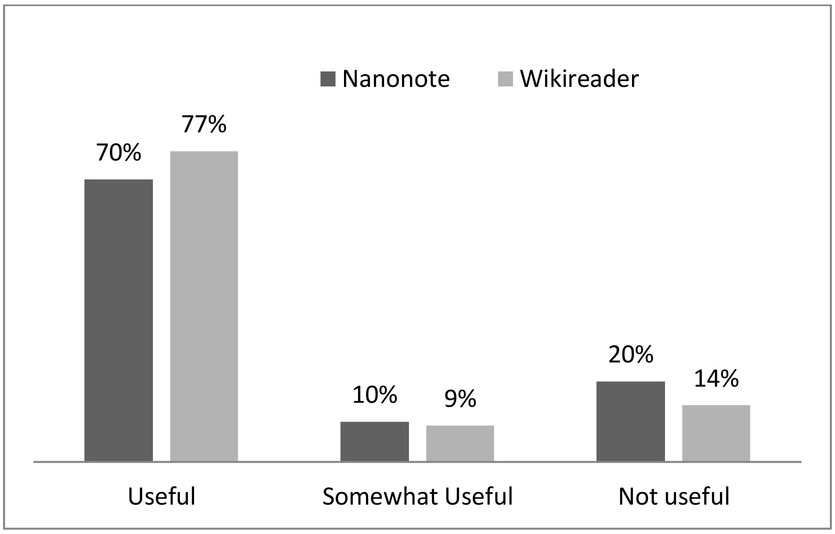


Figure 17: The analysis of the results from the total number of activities students completed in the Nanonote and Wikireader devices

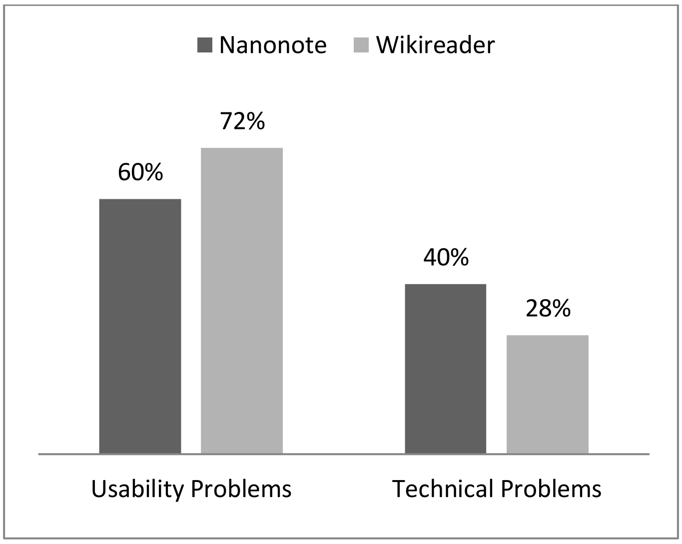


Figure 18: The analysis of the total number of problems students encountered while using the Nanonote and Wikireader devices

4.10 Social technology (DS) & Interaction learning (LS)

The Wikireader and Nanonote devices are not equipped with various technical capabilities, such as short messaging service (SMS), telephony, and access to the Internet through wireless networks. Therefore, these devices do not enable active communication between the students and tutor.

Nevertheless, to maintain the existing culture of physical and virtual cooperation and communication between students' and tutor in the classroom, lab and through Blackboard virtual learning environment and facilitate learning by introducing these devices (Koole, 2009), students were also encouraged to engage in problem solving activities and where possible exchange knowledge and collaborate. It is however important to fully explore the social technology and interaction aspects of using mobile devices which are important to fully utilize the affordances of the devices especially in the context of mobile distance education and blended learning (Kenny *et al.*, 2009b).

4.11 Limitations

The aim of this study was not to identify and measure the impact on learning embedded programming and also not meant for generalising the findings to a larger population due to small number of students' participation in a short period of the study. Therefore, the findings of this study should be used with caution to inform other programming education related studies.

As this study mainly focused on the device usability, the results only provide indications on students' perceptions towards the effectiveness of open-source platforms for student support. But the findings could be useful to support the adoption of offline mobile learning model to provide an access to resources and support learning.

4.12 Conclusion

With the lack of high-end or 'smart-phones' in the investigation, the findings highlight the difficulty of developing a sustainable mobile learning solution in the University of West London. Therefore, this research focused on developing systems for more cost-effective (under US$100) open platforms that support customized content for learning purpose.

This chapter reported an exploratory evaluation study of relatively low-cost research-oriented open-source mobile devices to teach embedded programming. It has helped to identify the benefits and limitations of the Wikireader and Nanonote devices by exploring how students perceived and used these devices, and how well they believed these devices supported their learning activities. This has also demonstrated the feasibility of a hands-on approach that can be used to improve the further use of such devices in teaching programming.

In this study, the Nanonotes and Wikireaders were perceived by the students to be an effective tool to support and learn embedded programming. An access to these mobile devices provided opportunities for students to use the devices throughout the term for learning. Students found Nanonote device useful for practicing hands-on programming for embedded device than general reading purposes. While Wikireader device can also be customised, students found it more suitable for uninterrupted anytime anywhere offline reading. Students were not concerned about the lack of wireless Internet access, as the devices were provided with required resources for the specific subject they were studying. Therefore, this study recommends further explorations of the potential of affordable open-source platforms, at least with the Nanonotes and WikiReaders to develop an effective and sustainable offline mobile learning solution to provide ready access to resources and support teaching and learning embedded programming.

Chapter 5

Teaching & learning in schools of Nepal with or without access to ICT

This chapter describes a preliminary qualitative study, carried out between August 2010 and July 2011 in public schools and private schools (which are generally believed to be better than public schools), with or without an access to ICT and use traditional teaching practices. The study was carried out to identify the challenges of education and technological needs in the context of Nepal with the focus on teaching and learning English language. It also identified the benefits and challenges of using ICT in poor schools and investigated how the use of ICT may be helping to solve some of the concerns. The question for which this user study aims to explore relate to the original research questions found in the introduction of this thesis. The question which is to be investigated in this study as defined below:

What are the challenges of teaching and learning English in schools of Nepal? Conduct exploratory studies to understand these challenges in the schools with or without an access to ICT. (Sub-studies 1 and 2)

5.1 Sub-study 1: schools and teachers and ICT in general in Chitwan

In Nepal, majority of schools are government funded. But the number of private schools is also increasing. Generally, students from private schools perform better than those from public schools and the pass percentage of school leaving certificate exam has significantly dropped in last three years. The commercialisation of education and the duel education system (public and private schools) of Nepal are two major causes of concerns. To address the pedagogical issues, this qualitative study focused on teaching and learning English language, which is not succeeding in public schools and the study also highlights the relevant issues of educational and social injustice in Nepal.

In the present education system, Nepal has both public and private schools. According to Government of Nepal's Central Bureau of Statistics[12], there were 34,335 public schools across the nation in 2014/2015. There is no official record of number of private schools available at the moment, however one of the Nepal's prominent local newspaper Republica[13] recently reported that there are 6,000 private schools in the country.

In the existing Education Act and the relevant Regulations, the school owned, managed, financed and regulated by government has been recognized as public or government schools, 'sarkari school' in Nepali, while the privately financed, managed and regulated by parents' association, business, non-profit organisation or a religious institution is called the 'institutional school' or private school (MOE, 2008). But the schools that are

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[12] Nepal in Figure 2015: http://cbs.gov.np/publications/Nepal_Figure_2015

[13] Republica http://www.myrepublica.com/news/4632 (Published August 29, 2016)

either funded by the government or do not receive a regular government grants and financed with support from community, donations from other sources and school's own resource, and managed by some non-government body, such as a community are called community schools, *'samudayik school'* in Nepali.

School Leaving Certificate (SLC) is a national level examination conducted at the end of grade ten. “Empirical research has demonstrated a significant gap between public and private school high school level test scores” (Joshi, 2014, p.59). . Due to poor passing rate from public schools, SLC is also referred as an “iron gate”. According to the Office of the Controller of Examination (OCE) [14], 55.5% have passed in 2011, which is 8.81% less compared to last year’s results and in this year 2012, only 47.16% students have passed the exam. In 2011, while near 100% private schools' students appearing in this exam succeeded, only 46% of public schools' examinees made it through. According to OCE and as reported in a local newspaper Kathmandu Post[15], in 2014 the pass rate for private schools was 93.26 percent while only 28.19 percent students from public schools managed to get through. The poor performance of public schools continues.

Therefore, as far as the results are concerned, private schools’ students are performing better than public schools and achieving higher. The wide difference in the pass percentage of the students gives an indication of the disparity in the standard of education. Now, the private versus public education is becoming an issue of even greater significance in Nepal.

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[14] SLC at a glance: Office of the Controller of Examinations http://soce.gov.np/result-at-a-glance/slc-at-a-glance/

[15] Kathmandu Post http://kathmandupost.ekantipur.com/news/2014-06-15/in-slc-results-public-schools-let-taxpayers-down.html (Published June 14th, 2014)

In Nepal, a large proportion of the rural population is illiterate, as the literacy is around 55% in which, Nepali (national language) is 82% and English is approximately 18% (ENRD, 2009). Approximately half of the population in Nepal lacks the basic skills of functional literacy and numeracy (MOE, 2009). Overall, only 43.3% of Nepal's women are literate, compared to 70.7% of men (MOE, 2010; Thapa, 2011).

In this chapter, the data form public and private schools are analysed to examine the challenges that schools face and highlight why the school education system is not effective in Nepal.

5.1.1 Study Approach

At the time of this study, there was no publicly available official list of all the private and public secondary schools to use as the sampling frame. Considering limited time and financial resources, a conscious choice was made of the place where the research was undertaken. A list of all the known schools in Chitwan district was made (see Figure 19) at the beginning of the study and from which eight public and eight private schools were selected to participate in this study. Within Chitwan district, all the schools were located in and outskirt of Narayangarh, which is a small town situated 140 km South/west of the capital of Nepal, Kathmandu.

16 teachers from 8 public schools and 16 teachers from 8 private schools were selected. To select the teachers to participate in this study, the most frequently used non-probability method which is a quota sampling was adopted. The only eligibility criteria for the selection was teachers should be teaching English subject for year 9 and 10. Due to reasons (differences between public and private schools) discussed in the section 5.1 above, the

even number of teachers from public and private schools were chosen to answer the particular research question (1.4.2) without undermining the sample design. Two teachers from each school were selected to provide unbiased results. From the eight public and eight private schools, thirty-two English teachers were selected to gain an overall deeper understanding of ways of teaching and learning, needs and concerns in schools of Nepal.

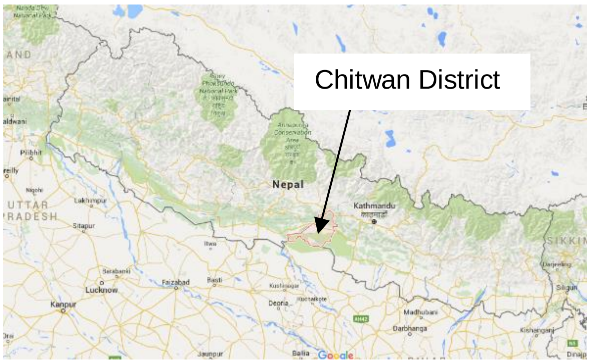


Figure 19: Sub-study 1 Research Site

The organization of this study and the data collection was completed in three months. Qualitative data was collected without researchers needing to be physically present at the site to supervise the study during the study period, which minimised the risk of influencing teachers' behaviour. The study also relied on the secondary data based on Nepal's established newspapers (e.g. Nepalnews, The Kathmandu Post, Republica and The Himalyans) that discuss the political changes and the Nepal's development in the present context. All the data were transcribed, summarised, coded and categorised manually.

"One particular feature of the Nepalese socio-cultural context is the fact that obstacles and complexities cannot easily be avoided without the help and support of someone who is well-acquainted with the 'gatekeepers'"

(Sapkota, 2012, p.105). A native social worker who was also a respected retired teacher, with his excellent local knowledge and rapport with the schools and the community helped to establish the relation with schools and the credibility of this research among the teachers.

Initially, head teachers of all the schools were contacted and permission to speak to teachers was requested. Some of the questions asked by a couple of participants at the beginning were: i) how much am I going to get paid for completing questionnaire? ii) are you going to give me the device to keep? iii) what is the value of this type of study while there are other pressing needs such as better facilities for teachers and students? Participations were given clarification as and when necessary to avoid any unethical approach towards the research study. None of the teachers were paid to participate in this research study. However, teachers were given a small gift in the form of a pen at the end of the study as it is a common and acceptable tradition to offer something to individuals for their voluntary contribution to someone else's work.

The written informed consents (Appendix F) from the teachers were obtained who agreed to participate in this study. Then the pre-questionnaires (Appendix C) were administrated and demographics were analysed. Then, teachers were provided a diary and a pen to enable them to self-report which also encouraged a sense of ‘ownership’ of the diaries, as both a process and a product (Hall, 2008). According to Jeffrey (2007), teacher diaries also generate a self-awareness which is beneficial for the personal-professional development of teachers, as they involve inwardly reflective procedure of writing about what happened in the classroom, and then analysing the entries for deeper insights.

Teachers diary were used to gain deeper understanding of how they teach and learn, how the courses are structured, what sort of resources are expected and what could be their motivation to adopt mobile technologies to support teaching and learning. It was hoped that this study will help to identify design implications concerning technology in the context of government schools using traditional teaching practices in Nepal and it may also help to design technological intervention that can hopefully scale by being more applicable to a wider range of schools and other learning contexts. But as this study was constrained to time and limited financial resources, there is a limitation on the generalisation that could be made on the findings of this study as the schools were located in a relatively developed (urban) part of the country, where supporting teaching and learning in rural area is even more challenging.

A paper-pen based diary study was conducted, as approaches such as combining data logging with e-diary in field trials (Liu et al., 2010) are more suitable for the browser/server based architecture and also due to the cost of implementing such an approach and the limited access to Internet technologies. Indeed, diary study can suffer from the drawback of potentially missing data, because participants forget to record entries or are selective in reporting (Bolger and Davis, 2003). Teachers are very busy and writing diaries require dedication as well (Jeffrey, 2007). It is also possible that participants may find it difficult to write unprompted (Hall, 2008).

In practice, the diary exercise turned out to be not successful because teachers did not have time or lacked motivation. A questionnaire was substituted. A list of 25 open questions (Appendix G) were provided that teachers used as guidance which helped to collect their thoughts and write down teaching and learning related experience. The questions helped teachers to articulate their perceptions and where available, the interpretations of their diaries are backed up by the findings from previous researches.

The questions focused on understanding the value of English language in Nepal's context, how English is taught in public schools, teaching techniques used, the social and cultural norms that are peculiar to each school, issues related to infrastructure, availability of resources and access to ICT, government and school's support in teaching English, the preconceptions about the role of ICT, mobile device in particular and expectations of how useful it would be in the context of learning. All the teachers added an entry to their diary in English language either in the school or at home. The choice of English medium instead of native Nepali language for writing diary may have affected quality and quantity of data collected in our study.

These studies also identified the type of useful resources for teaching English by understanding how teachers go about preparing lessons; what type of information they use to prepare lessons; where do they get the information from; how do they share material with fellow teachers and if there was a device to help prepare lessons what content would they like to have?

All the diaries were transcribed, summarised, coded and categorised manually. In this chapter, the challenges of achieving the objectives proposed by the English curriculum of government funded public schools of Nepal are presented which highlight why teaching and learning English is not effective in public schools. Finally, the name of schools and teachers have been anonymised in this study to protect the identity.

5.1.2 Demographics

The majority of public school teachers were comparatively younger than private school teachers, mostly with permanent jobs and were above the age of 36 while private schools' teachers were below 35. Out of sixteen English teachers from public schools that participated in this study, only two teachers were female. Out of sixteen private school English teachers, three were female. "Despite the increase in girls' enrolment in school education, a significant disparity in the teaching profession remains between men and women in Nepal" (Sapkota, 2012). However, according to the recently published Education for All global monitoring report (UNESCO, 2015), due to explicit policies for female recruitment, the share of female primary teachers in Nepal rose from 23% in 1999 to 42% in 2012.

Age Group	**Public Schools**	**Private Schools**
18-25	1	1
26-35	3	10
36-45	7	5
46-65	5	-
Total number of teachers	16	16

Table 3: Demographics of English teachers

Out of sixteen public schools' teachers, ten teachers had access to desktop computer at home and three had access at school. Out of sixteen private school teachers, fourteen teachers had access to computer mostly at home and at school or cyber café. Two private schools' teachers and three public schools' teachers had no access to desktop computers and no experience of using them as well.

All the public and private school teachers with an access to computer had a low to average desktop using experience. They used computer mostly for personal or study purpose and the Internet usage was rare. None of the teachers used computers for teaching English language in schools.

However, all the public and private school teachers owned low to mid-range mobile phones and had an average to a lot of experience of using the phone. Ten out of sixteen public school teachers owned low to mid-range Nokia phone (models range: 1600, 6030, 6085, 6120c), and the six teachers had a Nokia 5800 music express, Samsung (e1160 and e2130), Benq and Motorola (model not mentioned), and also a Chinese G'Five V80 mobile phones. In the private school teachers group, one teacher owned Samsung (model not mentioned), two teachers owned Sony Ercission (c902) and the thirteen teachers had low to mid-range Nokia phones.

Only two teachers each from public and private schools group were on contract (post-paid) plan and the rest are on 'pay as you go' (pre-paid) plan. Overall, three teachers have limited mobile internet using experience and all the teachers used their mobile phones mostly for making calls and text messaging. However, twelve private schools' teachers said that they use mobile internet for browsing web sometimes while three teachers access internet almost every day. Most of the teachers were concerned about the cost of using mobile internet. Some of them did not need to use mobile phone for browsing as desktop use was sufficient for them and when available, some teachers thought accessing internet on mobile phones would be inconvenient and some preferred desktop computer to mobile device for accessing the internet.

5.1.3 The English language

The motivation to teach and learn English is clearly driven by the understanding of its value in a much broader context. The importance of English language is such that teachers refer it as an international (global) language, a popular language, a practical language, a must-have knowledge and a passport to travel all over the world. In higher education, the importance of English is even greater as it is the preferred language to access the scientific literature and the economic opportunity in employment abroad (Hall et al., 2009). Therefore, “private schools are considered to be preferable to public schools because they teach in English medium and are perceived to be more managerially efficient” (Joshi, 2014, p.59). One of the teachers highlighted the importance of English language:

English is the language of a modern technology. It is important to teach English because most of the valuable books are written in English and medicines, newspapers, computers knowledge are in English language. English is for getting good job in the context of our country (Nepal). *It is for higher education, and for studying abroad.*

Thus, even though providing localized resources will have wider use and impact in Nepal’s education, it is believed that English based resources are also useful for students and teachers. But, English education is not succeeding and to provide access to digital resources and to introduce ICT for developing education, there are significant challenges that need to be considered.

5.1.4 Teaching techniques in public schools

English curriculum and textbooks are designed and developed to improve communicative skills; fluency and accuracy in communication are therefore desired goals. But teaching English is not succeeding in public schools due to use of grammar-translation method and chorus drills in their lessons and the limited use of pair and group activities, which are central to communicative language teaching (CLT) in the West (Shrestha, 2008).Teachers find it difficult to apply appropriate techniques of teaching as one of the teachers described the teaching in public schools as an act of depositing, a phenomenon similar to the Banking view of education eloquently described by Freire (Freire, 1996):

Worse yet, it turns them (students) *into containers into 'receptacles' to be 'filled' by the teacher which they patiently receive, memorize and repeat. The more completely he* (teacher) *fills the receptacles, the better a teacher he is. The more meekly the receptacles permit themselves to be filled,* the *better students they are.*

In public schools, students find very difficult to learn English. Therefore, every item is translated into the vernacular language. Students' inability to communicate is mainly due to lack of interactive/communicative activities in English-language lessons (Shrestha, 2008). A teacher highlighted the use of such method and its consequences in learning:

It is because they (students) *study all other subjects in Nepali medium and English is the only subject they learn in different language. Therefore, most of the schools' English subject is taught by translating in native language, which at the beginning phase sounds suitable, but in the long run it has adverse effect upon the students' ability to understand English and speak fluently.*

Another teacher said:

Using such method, teaching and learning English language becomes tough and gradually students pay less attention to learn the language. Eventually, the motive of teaching and learning English is considered as passing the examination rather than making the students communicate in real life situations and their weakness even promote them to cheat in the exams.

Public schools lack physical facilities and resources, especially the over-crowded classrooms and the imbalanced teacher-student ratio across schools. In the research, the average class size for public schools was 56 students per class. But, in private schools, the average class size was 34 students per class. According to the Education for all global impact report, in Nepal, the student/trained teacher ratios decreased from 260:1 in 1999 to 28:1 in 2013, a huge improvement due to a policy of upgrading teacher qualifications to require additional training (Dundar et al., 2014 cited by UNESCO, 2015).

To teach English language, private schools teachers' focus more on students' participations and they are interested in using student centred communicative language learning approach, which is, however, not always possible. As one of the private schools' English teacher said:

We have been mostly teaching in a traditional way which students don't like. On the other, resources for modern methods are not available easily.

In private schools, generally students perceive English as an easy subject, as one of the major differences between the public and private schools is that the private schools are English medium, and in public schools, English is taught as only one of the compulsory subjects, "In spite of the Education Act, which requires the Nepali language as the medium of instruction, these private schools use English as the primary language of instruction" (Thapa, 2011, p.31).

The most important difference between public/private schools was private schools' teachers did not use translation method and students were required to communicate in English language. Students were also provided with opportunities to interact regularly and participate in English language learning activities like spelling tests. Students were also encouraged to participate in group works and extracurricular activities and where available visiting school library at least once a week is compulsory. Private schools also had students' clubs such as ESS (English Speaking Society) to improve the English environment of the school. But students had rarely or no interactions with English speakers outside school and so the public school students.

5.1.5 The English learning environment

Students in public schools have rarely or no interactions with English speakers outside school. But the schools also lack English learning environment within the school and rarely use English language even in the classroom. Therefore, a teacher said, “English is difficult for not only the students but for the teacher as well.” Some of the teachers provide private tuitions for students from their own school or from outside as the students seek extra classes to pass the exam with good marks. “Private tutoring is generally associated with income generation activities among teachers seeking to supplement low salaries” (UNESCO, 2015, p.202). A study of a Private tutoring in English (PT-E) for secondary school students in Bangladesh showed that the students saw private tutoring as imperative for successful learning achievement (Hamid *et al.*, 2009).

Based on the observation of one of the teachers, the root cause of weakness in English starts from primary level and the concerns should be focused on this level. It has been highlighted that in some schools the students from primary classes are graded every year in upper classes though they almost failed in English. As a result, when they reach secondary level, the English teachers face bigger challenge of teaching the language. Shrestha (2008) found the lack of training of primary schoolteachers, which means there may be even fewer primary-school English teachers with appropriate skills and knowledge to teach English to young children. According to MOE (2009b, p.3), “On one hand, all school teachers are not trained and on the other, trained teachers do not get enough teaching material to make teaching and learning process effective”.

Though teachers had to teach average 25 hours a week, they also pointed out that the allocated time for teaching English is not enough, as only 5 periods are provided in a week to teach English per class.

5.1.6 Social divide

In this study, the teachers highlighted that the different cultural background and economic status in the community is clearly affecting the teaching and learning practices as well. Children lacks motive to complete basic education because of the perceived low returns of education. Circumstances are such that:

Due to the guardian's illiteracy, lack of knowledge and poor economic condition, they do not know the value of education and unable to provide good environment and want their children to stay at home and support in household work. As they have to work and support their parents in the morning and evening, students from these very poor families don't attend class regularly.

Nepal is a small land-locked country where most of the countryside is remote and about 42% of the population lives below the national poverty line. It has the rugged topography, high mountains in the north, hills in the centre and the Terai in the south. Nepal's geography is such that there are urban/rural differences in access to markets, services and information (Bennett, 2005). There are over thirty-six distinct ethnic groups living here and speak over fifty languages, with diversity in tradition and their culture. The current society, the past and the present institutional arrangements of Nepal have been directly or indirectly influenced by the geographical and socio-culturally diversity of the country and "disparities in gender, ethnic and economic groups, and locations are increasing year by year" (Thapa, 2011, p.3).

Historically, the caste system has existed in Nepal that was set-up to consolidate power by incorporating the diversity of a geographically and culturally divided Nepal. Nepalese citizens were divided into high-caste Hindus and low-caste untouchable Hindus. But, traditionally, highest-castes considered themselves superior and lower-caste were deprived from education, political capabilities and economic privileges. By law, it circumscribed civil liberties of lower-castes, ability to interact freely with others and they survived on low-paid manual work considered defiling by higher castes. During the 104 years of Rana regime until 1951, the education was considered an exclusive privilege of the ruling elites and access to education was deliberately restricted to them. Therefore, “social exclusion limited the living opportunities by playing a constitutive part as well as instrumentally a cause of diverse capability failures” Sen (2000, cited by Zheng and Walsham, 2008).

Although caste discrimination and oppression is officially illegal now and the inclusive system have opened some opportunities, it is still found in practice and the Nepalese male-dominated society is failing to represent the disadvantaged and sense of injustice still remains. The implication of deep rooted social divide is such that it has shaped the hierarchical structures of class and status in a present day society. As in the context of China, Zheng and Walsham (2008) highlighted the strong component of power hierarchy in the Chinese culture where inequality is taken for granted and people are still being deprived of the capability of taking part in public affairs and monitoring the performance of the government.

The gender discrimination, caste and ethnicity-based social stratification of Nepal has played its part in Nepal's culture, tradition, politics, and increasing the poverty. According to the United Nations Development Program, poverty in Nepal has increased over the past three decades, especially in rural areas (UNDP, 2010). Today, "Nepal – remain deeply hierarchical and those at the bottom of the hierarchy face entrenched economic, political and even spiritual and psychological barriers to access, voice and mobility" (Bennett, 2005). The members of historically disadvantaged lower castes continue to be socially excluded and are the poorest, while the upper castes tend to have the higher status and political upper-hand.

5.1.7 Schools divide

The increasing commercialisation of schools is affecting the public schools and the majority of poor. The serious consequence is that the private and public schools are seen as two opposite poles and therefore the schools divide is increasing.

Private schools are performance oriented and the quality of education is believed to be better than the public schools mainly due to the differences in the schools learning environment and better availability of resources. They focus in achieving the better results to meet the expectations of management and higher fee paying guardians. But, teachers expressed their concerns about their working environment:

Teachers in private schools are overworked, under constant pressure to perform well but in public school, there is no effective means of monitoring and evaluation. Provided that they (teachers) are not going to be evaluated, *negligence does occur. But public school teachers are better-off in terms of benefits like salary, pension and stable jobs. Therefore, private school teachers often change schools when offered better pay.*

Private schools are seen as profit-oriented, have an expensive fee structure and books that the poor cannot afford. Parents choice of schools are strongly constrained by their ability to pay school fees (Joshi, 2014). An average annual cost per student is US$ 65 in public schools whereas it is US$ 205 in the private schools (MOE, 2008). According to Asian development Bank, “Nepal remains one of the poorest countries in the world, with per capita income of $447 per annum, wide income disparities, and poor access by a large section of the population to basic social services” (ADB, 2009). Owing to this, private school education is not accessible to many and becoming privilege for families of higher socio-economic status who also prefer to send their children to private schools. The majority of students in a government school are from underprivileged/marginalized group, backwards and schedule casts. Often, children from poor families miss out schooling opportunities and dropout rate is also high. In this way, when it comes to the learning aspect, the impact of positive peer effects is greater in the case of private schools than public schools (Thapa, 2011).

Joshi (2014) analysed the differences between parental involvement in different types of schools in Nepal. The data on parent decision-making was collected in two districts of Kathmandu and Chitwan in 2011 and involved diverse set of schools’ types: smaller private schools, well-known private schools, below average public schools and average and better public schools. The study found the parents who chose smaller private schools had stronger engagement with the school and their children, were more likely to voice their concerns, and consequently were more satisfied. But the parents in below average public schools were more likely to express dissatisfaction but had limited interactions with schools to remedy their concerns. The study highlighted one of the reasons for the limited parent–teacher interactions in public schools is due to the socioeconomic gap between the well-educated teachers and the relatively disadvantaged public school parents, which may help perpetuate and even widen inequalities in developing countries such as India or Nepal.

There is also a significant increase in the demand of English education at the community level and therefore the preference for the English medium schools as it helps to fulfil the parental expectations. Public schools' student, those who fail SLC exam are unlikely to get a job or continue their education. Those who succeed are also unable to get admission in expensive and highly competitive English language oriented technical institutes.

The current government aims to reduce a gap between the poor and rich has been by introducing the mandatory education tax to fees paid by students in private schools to invest in poor schools in rural areas. Initially, it was set 5%, which has been reduced to 1% after the protest and yet there are demands to scrap the tax completely. Due to the serious consequence of the differences in the education system, the teaching and learning practices and the performance of public and private schools, the schools divide is deepening the social inequality that already exists even further by dividing the society between rich and poor in a Nepalese ethnically diverse and complex society. It is, therefore, crucial to identify alternative methods to manage and allocate resource, help poor access the better education and address the deepening differences between public and private schools.

5.1.8 The lack of resources

In public schools, the lack of teaching materials is also a major problem. Poor students cannot afford to buy reference materials and practice books, as highlighted by a teacher:

Almost all the government schools say that they don't have money to buy books, magazines and newspapers. As a result, pupils are deprived from reading extra materials. They have to rely on the textbook only. For listening activity, they don't have cassette player. If they have, there is no facility of electricity. There are a lot of attractive books available in bookshops, but students cannot afford to buy them, because most of the students in government school have poor background family.

Previously, Nepalese students were described as passive learners (Watkins and Regmi, 1990). But, poor studentsare unable afford to buy reference materials and practice books. As computing is almost nonexistent in the great majority of educational institutions (Goodman *et al.*, 2000), even today, education is still traditionally text-book oriented and therefore dependent on teachers as only reliable resource.

In some rural school, there are even cases of waiting for months for textbooks to arrive. Private schools are, however, better resourced. Where available, students can use computers but for information technology related activities only.

In Nepal, there is also a shortage of relevant materials in local languages relevant to their needs. Including the technical challenges of developing suitable services to provide access to digital resources, one of the harder challenges of delivering localized learning materials in Nepal is the English language itself. Despite low levels of familiarity with English language, as highlighted before, its importance and socioeconomic value is very high (Hall *et al.*, 2009). Goodman *et al.* (2000) also states that "unlike other one-country languages, Nepali suffers from not being universally spoken even in its home country". According to Shrestha (2008) "Even though, the English Language Teaching (ELT) situation in Nepal is far from satisfactory, it has affected the society as a whole, particularly the English-vernacular (Nepali) divide in the country".

The National Curriculum Framework (NCF), 2006 has emphasised on the need for education in mother tongue, and incorporation of local contents in school curricula. A recent study MOE (2010) carried out by ministry of education reviewed the existing status of local contents, and mother tongue education and highlighted the major challenge is to change the English language oriented mind-set into the mother tongue. The study showed the significant increase in the demand of English education at the community level. The two reason that the schools are using optional English as a local curriculum instead of promoting the local knowledge are, "First, it helped to fulfil the parental expectation; Second, it has made easy to the schools and the teachers to implement the local curricula as they do not need to take further initiative of developing the local curricula and the curricular materials".

5.1.9 The infrastructure

Nepal faces the biggest challenge of establishing the proper information infrastructure as the topography makes it extremely difficult to develop the much-needed telecommunications infrastructure.

MOE (2009b) states that “The government’s policy is to build a school around half an hour walk from the child’s home” and all the schools involved in this study are conveniently located in or the outskirt of Narayangarh town. But, teachers were concerned with the lack of physical facilities, especially the over-crowded classrooms and the imbalanced teacher-student ratio across schools.

Only income source of a public school is the grant/subsidy provided by the government, which means many public schools are unable to spend for any other activities (MOE, 2008, 2009). The lack of well facilitated rooms and proper teaching aids especially to use in the classroom are the major problems faced by teachers and therefore they find it hard to use the informal teaching methods. Electricity is available in these schools but very unreliable. While Nepal electricity authority is planning for further power cuts and hike the electricity tariff by 30 percent, the use of multimedia equipment even a cassette player is not common in the classrooms. A teacher expressed his frustration:

Load-shedding is sometimes more than 12 hours. So it has adverse effects upon teaching and learning activities. It creates problems to run our already limited computer classes and other ICT programs.

5.1.10 The political instability

The worsening political situation in Nepal is the foremost and the major concern that is destabilising the country. It has been more than 5 years since a 10-year civil war between the state and the Maoist rebels has ended. However, the country is still suffering due to a political instability and weak governance, and there is no certainty when this transition phase will end. The impact is felt in every sector and clearly hampering the possible growth. Because of the constant feud and disagreements between Nepal's biggest parties, the nation continues to operate in a fragile state (Joshi, 2014). Though Nepal is formally declared a Federal Democratic Republic in 2008 and a constitution has been written, there are still differences among the parties on the contentious issues of federalism based on ethnicity or caste divisions.

Considering what is currently being done from the government level to revitalise the educational practices, teachers stated that there is a lack of clear policy about education and believe that Nepal is not on the track to achieve the goals of Education For All (EFA) by 2015 (MOE, 2009). Schools lack investments from government level in novel educational techniques and support teaching. There is also mismanagement of available resources within the schools; the politics influence almost every aspect of schools' management and the quality of education. All the teachers voiced their deep concern:

We are facing the situation of anarchy. Everywhere in the government schools, there is a direct and indirect interference of political parties. The involvement of teachers under certain political umbrella is one major cause *for loosing standard of government schools. The schools open for only 150 days, while it meant to open for at least 220 days according to the government calendar.*

Until and unless the unnecessary political interference within the school is rooted out, it will be impossible to establish the transparent educational environment and improve the education in Nepal. Regularly, both the public and private schools across the country are closed down on issues such as demand of permanent status to temporary teachers, teachers of private schools be provided salary and allowance on par with their counterparts in community schools, appointment letters be strictly enforced, the policy that categories schools under the Company Act be scrapped and vacant posts of teachers be immediately fulfilled.

Though there is no or limited political interference within private schools, these schools are a part of an ongoing national debate as the questions are constantly raised about how they operate, the higher fees they charge and their overall contributions to the education and the society. While there are evidences of decreasing number of students attending public schools, lack of control over new private schools is also one of the major concerns. There are some private schools running classes without approval from the government authorities.

The social and political unrest in the country and the lack of clear policy about education, establishment of schools, its structure, management, allocation of resources and how it function has increased the differences between schools, affecting the overall quality of education and the nation's future.

5.1.11 Access and role of ICT

In higher education of Nepal, English as a medium of instruction is widely used than at school (Shrestha, 2008). Referring it as a critical situation, a teacher stated why it is so important to improve English language teaching in public schools:

Our previous records show that the students from government school, as they are weak in English, unable to get admission in technical institute. And, to avoid this, our total attention should be paid on course book design, resources and the techniques used.

In this study, most of the teachers stated that the introduction of technology into classroom will help both teaching and learning process. As one teacher expressed his positive perception:

The traditional way of teaching is out date. Chalk and duster which has been only tools of teacher need to change. Computer, projector, cassette player are supposed to be urgent requirements for the school which are out of our access. I think ICT will facilities us to teach and learn better English by making our task motivating and effective. It may create a rich environment for language learning. It offers great potential for student interaction and practice with authentic communicative language functions.

Indeed, GPRS/3G networks and handsets are becoming cheaper. However, regardless of the fastest growth of mobile phones in the poorest regions (Heeks, 2008); common use of expensive smart phones is not yet possible in public schools of Nepal. Most of the teachers that took part in this study have said that they and the students do not have basic knowledge of using ICT, as in most of these schools, computer lessons are not part of the curriculum mainly due to the lack of funding support. A teacher stated:

We have just seen and heard about ICT but we don't have basic knowledge of using ICT. Only a few teachers and hardly a small number of students have access to ICT. Some schools may be equipped with ICT while the most schools have no access to it.

A couple of schools that have computers are being used for accountancy or some other official purpose. Those schools with a limited computer access do not use it for teaching and learning English as one of the teacher mentioned:

Our school has run computer as an extra subject since last year only for the students of lower secondary level. Only computer teachers are involved in this subject.

In these schools, the affordability of computing clearly is a major issue and teachers' low computer proficiency also affects their ability to create digital content needed for teaching. Therefore, even though the innovative but simple solutions such as Multiple Mice project (Pal *et al.*, 2009) can provide financial and learning benefits, it is important to design a product that supports simplified process for teachers to engage in technology-mediated learning.

5.1.12 Mobile platform

Relatively cheaper mobile technology, compared to desktop computers and laptops, has more realistic adoption possibilities and help both teaching and learning process. A teacher said:

These days it seems mobile phones are used everywhere by everyone. They are increasingly powerful devices. Most importantly phones are social tools that facilitate authentic and relevant communication and collaboration among learners. By using mobile device, I think we can motivate students and encourage them to participate in class activities.

Mobile learning researchers around the world are focusing on integrating smart mobile devices (such as iPhone and iPod Touch) into educational institutes' curriculum and support formal and informal learning. English in Action is one of such current project in the context of Bangladesh (for more detail, see Power and Shrestha, 2010). But the cost of the device is also one important factor (Chhanabhai and Holt, 2009).

Teachers stated that introducing mobile technology in schools will require financial support as the students are from poor background and for its successful adoption it is important to be a part of existing curriculum. Therefore, to deliver and support learning as a key aspect of a sustainable mobile learning solution, it is important to consider an appropriate target mobile platform before proposing, developing and piloting such solution. Including the cost for the device, it is also important to consider the cost that users may have to pay for using the mobile services.

5.2 Sub-study 2: the impact of XO laptops in four OLE districts

Nepal's education sector faces major challenges of providing quality education to the majority of the population due to disparity in education quality and access among school types as identified in the sub-study 1. Vast majority of students in under-resourced schools do not have access to all the learning materials. Even regular text-books do not arrive in time. OLE Nepal aims to address this problem through the integration of ICT in education. The aim of this study was to examine the benefits and challenges of using ICT in schools and understand how the use of ICT may be helping to solve some of the concerns discussed as above in this chapter.

5.2.1 Open Learning Exchange Nepal (OLE Nepal)

Even in a poor country, it is clear that one of the current and the urgent educational requirement is to provide an access to digital resources to support teaching and learning. OLE Nepal[16] is a social benefit organization with the focus on enhancing teaching-learning in rural public schools through the integration of technology (XO laptops), in many cases schools in remote location without basic infrastructure and where most of the teachers and students have never used computers in their lives. OLE Nepal develops and distributes free educational content that is accessible even without the Internet and trains teachers to integrate technology in classrooms.

OLE Nepal has connected more than 57 schools from different parts of the country providing local access to digital library and also introducing OLPC to participating schools since 2012 (see Table 4). In those schools, XO laptops are only available to use for students up to year 6.

Table 4: OLE Nepal deployment until 2012 (Source: OLE Nepal)

	Trained Teachers	OLPC laptops	No. of Schools
OLPC Project	**500**	**3257**	32
Shared Model	**121**	**590**	17
Digital -Library only	**27**	**0**	8
Total	**648**	**3847**	57

[16]OLE Nepal: http://www.olenepal.org/

5.2.2 Study approach

During the preparation of this study in early 2011, OLE Nepal was approached to discuss the planned study. Then OLE Nepal provided the official list of all the schools they supported, which was used as the sampling frame. Once again, considering limited time and financial resources, a conscious choice of the place was made where research to be undertaken. For this study, 8 under-resourced rural public schools from 4 different districts (Makawanpur, Lalitpur, Mustang and Kapilvastu) of Nepal were selected (see Figure 20).

To select the teachers to participate in this study, once again the most frequently used non-probability method was used which is a quota sampling. The only eligibility criteria for the selection was teachers should be teaching English and has experience of using XO laptops for teaching and learning. As they were all primary schools, one teacher from each school was selected to gain an overall deeper understanding of ways of teaching and learning and challenges of using XO laptops.

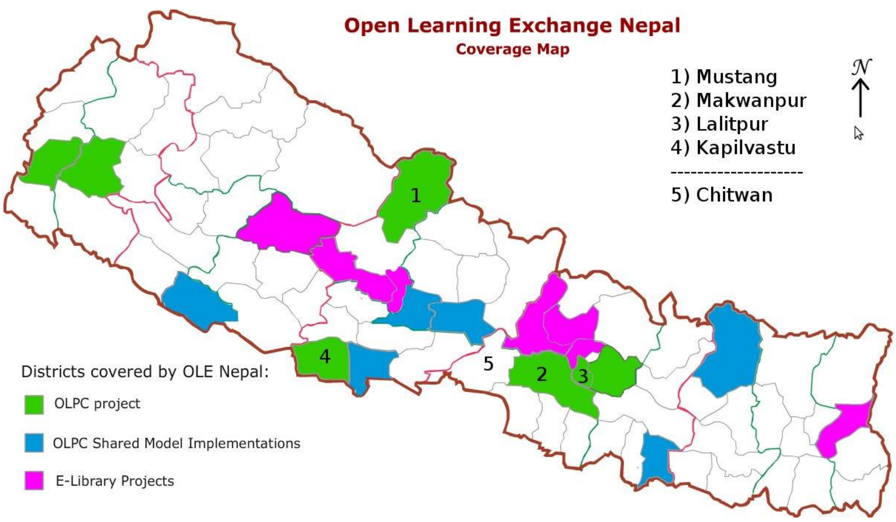


Figure 20: Sub-Study 2 Research Site (Picture adapted from OLE Nepal)

The organization of this study and the data collection was completed during researcher's Nepal visit to conduct the sub-study 2. Due to lack of financial resources and difficulty of travelling during the monsoon season in Nepal, not all schools could be visited. Therefore, six English teachers were interviewed over the telephone. Two of the schools were visited to observe the use of XO laptops for teaching and learning and two of the English teachers from these schools were interviewed on site. All the data were transcribed, summarised, coded and categorised manually. The names of schools and teachers have been anonymised in this study to protect the identity. In the below section, the findings of this sub-study is presented.

5.2.3 Scale and sustain ICT programs

Due to the support infrastructure put in place by OLE Nepal, the handful of public schools with access to XO laptops have shown improvement in the learning environment where students are enthusiastic in learning and collaborating and teachers are more motivated and eager as well. According to teachers, that is mainly due to interactive learning activities which are localised content based on school's curriculum. There is also evidence of increase in student enrolment and retention but an unexpected consequence in other local schools within the community as highlighted by one of the head teacher that usage laptops in his schools:

One of the implications of this XO laptops usage is such that nearby public schools without an access to these laptops have suffered as the students from the community intend to study in our school so they can use the laptops.

Table 5: Use of OLPC in under-resourced remote primary/lower-secondary schools (year 2 to 6) for teaching English, Math, Nepali & Science (for year 5 only). Data collected in 2012 (Source: Author)

School	Number of Students	Avg. Number of Student/ Class	Number of Teachers	Number of Trained Teachers	Number of XO (OLPC)				Years running
					Lost	Not Working		Total	
						XO	Chargers		
Mustang 1	300	25	22	7	-	-	10	92	2
Mustang 2	103	11	18	5	-	4	Few	35*	4
Lalitpur 1	250	30	20	9	-	-	Few	92	3
Lalitpur 2	150	25	9	5	13	3	10	83**	3
Lalitpur 3	175	20	13	9	-	22	Few	124	3
Makawanpur 1	300	30	11	8	-	25	45	142	2
Makawanpur 2	300	30	13	9	-	8	20	80	2
Kapilvastu 1	212	30	11	5	2	-	10	112	2

*Initially, they had 43 XO laptops. Because of fewer students in year 6, 8 XO laptops were taken back from OLE Nepal. **Out of 83, 35 laptops are returned to OLE Nepal. (Few = exact number not know)

In fact, in Nepal, the computer lab is seen as a status symbol for the remote school even though it is not used by students much (Raven, 2013). However, eight remote schools that participated in this study (see Table 5 above) were still using the XO laptops for teaching and learning with the support from the OLE Nepal. But these schools were not able to scale and sustain running laptops for education themselves. They were completely dependent on a support from OLE Nepal to manage it. They were not able to build and maintain the required supporting infrastructure and lack local technical, logistical and financial capacities. For example, because of the remoteness of the many schools, teachers are unable to get in time technical support/update from the central office in Kathmandu and many laptops remain unused, not necessarily broken. As one of teachers explained:

Sometimes, I have to make a journey to the head office with the laptops to get it fixed and travelling in Nepal from remote places is not easy.

Teachers find training as an important part of the program. It is more than necessary for them to be able to integrate the technology in the classroom. But they thought it would be more effective if they were also given a basic technical training to keep the devices up and running.

Though there are many obstacles to scale and sustain XO laptops use in schools, seeing the benefits of using technology in a classroom, overall teachers were satisfied with the use. Having an access to mobile phones, one of the teachers expressed the possibility of using mobiles for a similar purpose.

It would also be useful to be able to access learning resources with other affordable devices like cheaper smartphones or tablets which could be easily fixed locally. Though availability of electricity in Nepal is unreliable and charging and running mobile devices could be challenging but that could be managed easily compared to XO laptops we are currently using.

5.2.4 One to one use of technology

According to teachers, even though these laptops were designed to support 1:1 learning model initially and children were allowed to take home, it quickly become the major concern for the schools. Schools have been provided limited number of machines and demand is always overwhelming. Children when allowed to take the laptops home, they didn’t have an electricity to charge the laptops. The irregular or a complete lack of power supply in the villages is the real challenge. Instead, fully charged laptop that students took it from school, some of them would leave it on in the evening to use as a candle.

These laptops are also vulnerable to theft, damage (broken screen, battery issues) and misuse. The biggest problem children had been with the power adapters and there was a time students were allowed to take laptop but not the power adapter. However, there were many cases of missing laptops as some of the children's family didn't have a fix address and migrated from one place to another for finding work and some children didn't turn up in the school. There were lots of logistic issue, challenges to monitor the usage of devices and making sure devices were all in a working order and students were bringing back the laptops. Not all rural schools have infrastructure to keep the laptops secure, plugged in and running in each and every class.

As Carly *et al.*, (2013) highlighted, "The main barriers to 1:1 programmes are the high costs associated with purchasing and maintaining a device for every student, and the need to work closely with education ministries to ensure effective roll-out". Since there were not enough laptops for each student, schools either started using or were planning to use a shared model whereby each class take turns using the laptops (see Figure 24). The idea was somehow similar to the traditional computer lab used on a set timetable providing students with access to the computer where a teacher always facilitates teaching and learning. Students were not allowed to take laptops home and not allowed to use in school outside that period set by a school. Therefore, it is far more important for teachers to acquire and develop ICT skills and capacity to successfully integrate technology in teaching and learning.

Figure 21: One of the schools, which adopted shared model that makes easier for schools and teachers to manage the program and has significant cost savings (Source: Author)

5.2.5 Online resources

In Nepal, Internet connectivity outside number of small cities is still very slow, unreliable or expensive. In case of most of the remote schools even non-existent (as shown in Table 6 below). However, in these schools, lack of internet connection was a mere concern but not seen as a limitation to quality teaching and learning. Even after establishing internet access initially, some of the schools disconnected as they were unable to afford the monthly subscription fee. Some of the schools lost the connection due to difficulty to maintain the required communication infrastructure. Availability and access to relevant learning materials was, however, very important and a major requirement. Therefore, OLE Nepal deployed digital library in these schools and setup a local network to provide an offline (desktop and wireless) access to the learning materials. It allowed automatically updating the content in the server by inserting an external drive with new content in the USB port. The library (pustakalaya.org) is also freely available online.

Table 6: Cost and use of Internet and its benefits to remote schools. Data collected in 2012 (Source: Author)

School	**Cost** (Currency: Nepalese Rupees) (US$ 1.00 = NRs. 99.96)		**Use of Internet and benefits**
	Electricity (per month)	**Internet / Provider (**per year)	
Mustang 1	1500	2000. Provided by NWP. Initial government grant of 8000.	Encourage to use in leisure time. Very slow, but works.
Mustang 2	1200	2000. Provided by NWP. Haven't paid for last 2 years. Initial government grant of 8000.	Internet - not really used. XO for only teaching. Students are not encouraged to use internet. We said we don't need internet as it disturbs teaching.
Lalitpur 1	500	-	No internet access. Not vital for education.
Lalitpur 2	600	1000. Provided by OLE Nepal. Two schools share the internet cost. They pay 6 months in turn.	Teach students for searching useful learning resources only.
Lalitpur 3	1200		Useful to support teaching and learning.
Makawanpur 1	1000	No cost. Provided by OLE Nepal.	Unreliable service. Not benefited.
Makawanpur 2	1000	No cost. Provided by OLE Nepal.	Internet issues with rely/antenna in trees. Lack of internet issue is not a concern but lack of learning resources is.
Kapilvastu 1	1000	No cost. Internet provided of NWP.	Not used due to technical issue. Unable to afford the maintenance cost.

According to teachers, offline digital library was just fit for the purpose for supporting teaching and learning as it enabled better user experience through fast access and quick downloads. They also find it has helped in understanding how technology can support overall education not just learning computer skills which has been a common misconception in Nepal's context.

5.3 Conclusion

The idea of this study was not to imply that the teaching and learning English in public schools is a failure. Instead, it highlighted the existing challenges and why English language teaching may not be succeeding in public schools. This inquiry has helped to gain deeper understanding of how the English teachers in public schools teach and deliver learning and what could be their motivation to adopt Information Communication Technology to support teaching and learning. But use of mobile technology (XO laptops) in public schools clearly highlights the major difficulty of scaling and sustaining such programs. It however helped to identify the shared model concerning the use of technology in the context of schools of Nepal and offline approach to learning. Future technological intervention can be designed, developed and evaluated based on this understanding. For this research, it has also helped to identify schools/teachers interest in the further study exploring the use of technology to support education described in next chapter.

Chapter 6

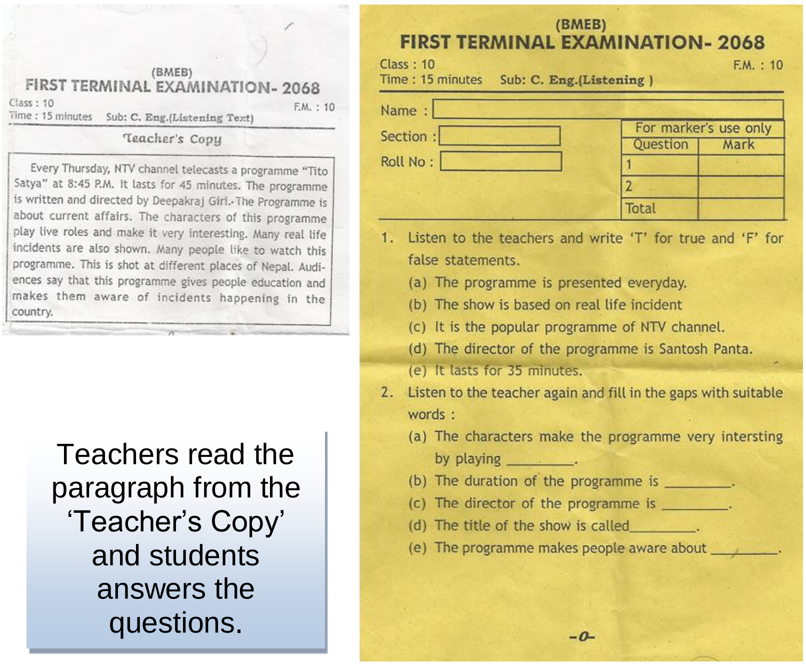
Sub-study 3: the innovation of low cost devices in schools of Chitwan

This chapter describes the study that explored how an offline mobile learning solution based on the Nanonote and Wikireader devices may facilitate English language teaching and learning in the challenging learning environment of schools of Nepal. The study was carried out between May and July 2011 for three months. The question for which it attempts to answer relate to the original research questions found in the introduction of this thesis. The question which it attempts to answer is as below:

What are the benefits and difficulties of using open-source mobile devices to support teaching and learning in the context of Nepal? Conduct a study to evaluate the use of open-source mobile devices and determine whether there are any aspects of teaching and learning English language that it can support.

6.1 The innovation of low cost devices in schools of Chitwan

In year 9 and 10 curriculums, listening skill is also allocated 10% of the total mark in the exam. In each unit of the textbook, there is a provision of listening lesson. For the teaching purpose, Curriculum Development Centre (CDC) has developed audio cassettes for classes nine and ten. But most of the schools did not have those listening materials. Teachers also ignored or did not give priority to listening skills and therefore it was not taught and tested properly as the course prescribed. In one of the schools visited, teaching listening skills had become a formality as bringing a battery powered cassette player and spending time fast forwarding/rewinding the tape to find the right listening material in a half an hour class was not seen feasible. Hence, teachers did the listening tests once a week/month or even just before the exam rather than end of each unit as required. Most of the time teachers just read the text themselves rather than using the cassette player (see Figure 22 for an example).



(BMEB)
FIRST TERMINAL EXAMINATION- 2068

Class : 10 F.M. : 10
Time : 15 minutes Sub: C. Eng.(Listening Text)

Teacher's Copy

Every Thursday, NTV channel telecasts a programme "Tito Satya" at 8:45 P.M. It lasts for 45 minutes. The programme is written and directed by Deepakraj Giri. The Programme is about current affairs. The characters of this programme play live roles and make it very interesting. Many real life incidents are also shown. Many people like to watch this programme. This is shot at different places of Nepal. Audiences say that this programme gives people education and makes them aware of incidents happening in the country.

(BMEB)
FIRST TERMINAL EXAMINATION- 2068

Class : 10 F.M. : 10
Time : 15 minutes Sub: C. Eng.(Listening)

Name :
Section :
Roll No :

For marker's use only	
Question	Mark
1	
2	
Total	

1. Listen to the teachers and write 'T' for true and 'F' for false statements.
   (a) The programme is presented everyday.
   (b) The show is based on real life incident
   (c) It is the popular programme of NTV channel.
   (d) The director of the programme is Santosh Panta.
   (e) It lasts for 35 minutes.
2. Listen to the teacher again and fill in the gaps with suitable words :
   (a) The characters make the programme very intersting by playing ________.
   (b) The duration of the programme is ________.
   (c) The director of the programme is ________.
   (d) The title of the show is called________.
   (e) The programme makes people aware about ________.

-0-

Figure 22: Script for listening test used in first terminal examination in one of the schools (Source: Author)

Please note even though this study was completed in July 2011, there are still issues and challenges that need to be addressed. In July 2013, MOE (2013a) conducted a study to explore the status of learning listening and speaking skills for year 9 and 10 students. Including the issues related to the teachers, students, a learning environment and the process used in teaching, the MOE report also highlighted the lack of cassette, cassette players, and the electricity facility at school. Insufficiency and problems remain in creating and maintaining supporting materials. The report recommends the use of modern technologies to improve teaching methods and testing. But there is no further literature available on the use of ICT to date.

Therefore, this study aimed at supplementing the existing listening skill practices by providing a much-needed access to those listening resources using an alternative technology platform. At the time of the study, there were not any contextualised mobile learning activities suitable to use with Nanonote and Wikireader devices in such a learning context.

6.2 Study approach

The focus of this study was to evaluate applicability of open-source mobile devices in a traditional teaching setting to support teaching English within a curriculum of class 9 and 10. The author is a native of Nepal and led this evaluative study. Two teachers from two private schools and two teachers from public schools participated in this study.

Selecting participants for this part of my research relied on 'snowballing' from the previous sub-study 1. "Snowball sampling suffers from the obvious limitation that participants are not selected randomly from the population, thereby limiting the statistical validity and generalizability of study findings. Nonetheless, snowball sampling is often embraced as the only way to approach hidden or marginalized populations such as low-income respondents in the developing world" (Vashistha et al., 2015, p.1). Based on the level of interest and willingness to participate in further studies, four of the teachers who had participated in that study were invited to participate in this study.

The advantage of this approach was that teachers were already known to the author and already had some level of trust between them. Author knew teachers' and their school's background, teaching and learning environment, their familiarity with mobile technology and higher probability of participating in the study and evaluate the devices. Only four teachers participated in this study as only four pair of devices were available.

The offline learning devices were provided to English teachers with customised contents for three months in selected schools. During a relatively short period of technology use, design and development of curriculum based mobile learning software and measurement of teaching and learning outcomes were outside the scope of this research study, which helped to focus on evaluating the proposed solution instead.

During the study period, teachers were frequently observed using the devices in the formalised context (Frohberg, 2006) of a classroom, without obstructing teaching and learning interactions and at times, informal discussion with teachers helped to identify the apparent benefits and also to raise other issues and problems. This evaluative study analysed the teachers' interactions with devices during the deployment period. Due to exploratory nature of this research, teachers were free to decide when and how they wanted to use the devices, how much time they could spend and what types of activities they would like to do with them. This flexibility allowed teachers to engage in mobile learning outside any constrains of research objectives. The evaluation was mostly informal and qualitative and data analysis was an iterative and reflective process throughout the research period.

Initially, the plan was to request teachers to complete written logbooks of their daily activities with the device, including the location, duration and type of activity, which will reveal patterns and frequency of use across location during the study period. But, as with the diaries at the beginning of the study, teachers did not show the interest mainly due to work load and other commitments. Therefore, at the end of the study, post-questionnaires (Appendix D and E) were used to ask teachers to indicate the frequency of use of the devices that helped to reveal patterns of use and interest over the given period of time. The purpose was to find out what features of the device they had used, whether they had found it to be a useful tool for supporting learning and teaching, what sort of strategies they adopted when using it and what the benefits and limitations were of using the mobile device for offline learning.

As the listening materials required for listening practice at the end of each unit of the course were only available on the tape, it was converted to MP3 using a cassette player, an audio cable and a computer with a free Audacity software. Then, the digital files were pre-loaded in Nanonote devices for teachers to use. Other useful materials for teaching and learning English - slides, documents and videos were also uploaded. Wikireader devices were provided with default Wikipedia content. Teachers were asked to keep the devices for the entire duration of this study.

During this field study, even though all the teachers were well informed about the ethical issues and they expressed willingness to participate, working with private schools' teachers was more challenging than the public schools' teachers. This could be due to their workload.

As discussed in Chapter 5, private and public schools in Nepal provide a very different educational environment. Private schools are generally profit-oriented and teachers are always under pressure to produce a good result and feel stressed by their workload. They generally spoke about the exams and how busy they were with the preparation in their interactions with the researcher. While I had no issues organizing public schools visits, classroom observations and meeting teachers for informal discussions as well, it was difficult to approach private schools' teachers. In private schools, I had to explain the purpose of the study again and request head teachers for permission to conduct the study. During the visit in one of the private schools, rather unexpectedly, once I was also asked to speak about the 'discipline and punishment: teacher and students' relationship' at the assembly. Though completely unrelated to the research and I was not an expert in that subject, I made my best effort to express my views solely based on my own experience when I was a student in Nepal.

This study further highlights the challenges (as discussed below) for successfully implementing a mobile learning solution in a developing country, as identified during observations. Finally, the name of schools and teachers have been anonymised in this study to protect the identity.

6.3 Teachers, technology usage and support

Out of four English teachers that participated in this study, only one teacher was female. The age of two teachers was below 35 and the other two varied from 36 to 65. Only one public school teacher had a permanent job and the rest were on temporary contract.

All the teachers had limited access to computer at home or cyber café but private schools' teachers had limited access at school as well. All the teachers had a low to average desktop using experience and they used the computer mostly for personal or study purpose. They had an access to internet but the usage was either infrequent or rare. However, they all owned a mobile phone and had an average to a lot of experience of using it. But all the teachers were on 'pay as you go' (prepaid) plan and used their mobile phones mostly for making calls and text messaging. They were concerned about the cost of using mobile internet.

To complement traditional classroom teaching activities, teachers require training using the devices and possible ways of increasing the blended learning experiences. But schools did not have the right infrastructure and capacity to provide the support, training and monitor if they wanted to use technology in their teaching. Therefore, even though teachers had basic exposure to technology, they never used technology to support teaching and learning English. This highlights lack of teachers' technical capacity and school's infrastructure reduce the possibility of successfully implementing the mobile learning initiatives in the context of a developing country such as Nepal. However, as one of the teacher said:

"Introducing easy to use mobile devices appropriate for supporting interactive educational activities could encourage its use as they can anticipate the benefits to teaching and learning."

6.4 Feasibility and usability of devices

This three months long preliminary study was conducted in order to assess feasibility of low-cost open devices (Nanonote and Wikireader) to provide offline access to learning resources. Evaluation of these devices shows that even though limited functionalities and usability issues restrict the usage of the devices in the classroom, teaching and learning opportunities could still be identified and supported that could engage teachers and students and help enrich learning. Teachers highlighted some of the apparent hardware/software/user interface related issues but that did not stop them using the devices. It is however far more important to provide easy to access contextualised learning activities that are engaging and the benefits should be obvious from the start.

6.4.1 Wikireader

All the teachers found the design of Wikireader device very simple to use and easy to learn the functionalities as it had only three (Search, History & Random) buttons.

"It is useful to search varieties of information you require. It can be carried anywhere you like.

"The size is also handy. The touch screen helps you to search the information in few seconds. It can be used by anyone who knows English. It is especially useful for students."

They frequently used the devices at home, school and while travelling as well. One of the teachers also found useful to use it in the classroom as a pocket-sized encyclopaedia to find information on new topics of interest as students enquired. The results from search function was instant but did not support full-text search which meant teachers needed to know the exact title of the article to search. As one of the teacher said:

“While searching needed topic, the reader need exact information of what we can find here.”

The history function was convenient but there were no forward and back navigation buttons in the device, which teachers highlighted as a limitation of a device. The Random button presented a Wikipedia article selected by chance which teachers mostly used in their leisure time.

The device only allowed viewing the text and did not allow editing or updating the content. Teachers found touch screen response was quick and font size good enough to see it anywhere/anytime you like. But the LCD screen was sometime difficult to read under poor lighting conditions due to the lack of a backlight. There was no issue of charging this unconnected device as it was powered by two AAA batteries that could easily last months. As the device was completely offline with no other connectivity; no Wi-Fi, no USB port, teachers thought these devices offer a lot of value as there were no issues of charging and lack of internet access. A teacher said:

“We can use it at anytime, anywhere, therefore, it can help us in our need to know the meaning of unknown word, place, dignitaries etc.”

Especially in remote schools where the course books do not even arrive in time, a MicroSD with updated software and content can be easily transported. Teacher suggested:

“It can be used as a classroom material for teachers and students.”

“As a teacher, sometimes we could enter the classroom without preparation. Because of the device, we could get the material easily which we were going to teach. Such as writing descriptive essays.”

“As a whole it’s a useful device. If students are provided with such electronic devices, they can be far better at English language.”

6.4.2 Nanonote

Teachers used Nanonote devices 2-3 times a week, mostly in the classroom. Two of the teachers found easy to use and other two teachers found somewhat difficult. For the length of time the devices were used, the battery life of the devices was not a cause of concern as charging Nanonote devices was feasible.

Teachers thought these devices could have wider applicability as it can play audio and video materials as well. All the teachers highlighted it as a main benefit:

“It has both audio and visual output. Though the size of screen is small the picture quality is good. We can use it as a teaching tool. It is portable in size.”

“As a teacher, I could use it my English classes for listening + speaking tests to make the teaching and learning more communicative and beneficial.”

However, teachers stated that lack of custom software, inability to upload, share and use the content without needing an external technical support and difficulty to use the keyboard were the limitations of Nanonote devices.

“It was somewhat difficult when I didn’t know how to use it at the beginning.”

“The functions and other usage of the Nanonote could not be used properly because of less knowledge about it.”

“I need a technical support to use the device. An individual has no access to input the data from other devices into the Nanonote.”

About the experience of playing videos, one of the teachers said:

“We can’t pause. We can’t play serially. We can’t edit it. We can’t go back.”

Similarly, teachers found using the keyboard and reading on this device challenging:

“It’s difficult to read on this device. The font size is too small to read conveniently. ‘Keys are not much convenient while using it.”

Therefore, all the teachers used the devices only for listening activity in the classroom, which needed minimum user interaction with the device hence less issues using it. But, the built-in speaker of Nanonote was not loud enough for a whole class to hear. As one of the teachers said:

“While using as a classroom material it cannot be used in a big classroom with students in a big number. It requires again another device to make the sound heard or loud.”

To overcome this problem, a teacher suggested to use an external rechargeable speaker which was cheaply available in the local market (see Figure 23).

Figure 23: Use of Nanonote to support listening activities in the classroom (Source: Author)

According to teachers, having a computer in a pocket could enhance teaching and learning if these devices were cheaply available, had software (with a very simple user interface) that is easy to use with very low computer skills and learning activities designed for its small 3-inch screen. Teachers general perception was that, *“it looks like a computer*” and *“it should be used in the broad sense as a computer.”* But teachers felt the display was too small to show to the whole class. Hence, a teacher said, *“It is more useful for individual use than a group of people.”*

However, it could be more useful if teachers could use this pocket-sized computer with a portable mobile projector for video materials to show in the classroom and increase the interactivity.

6.5 Digital learning resources

In public schools, the lack of teaching materials is a major problem, which was discussed in the previous chapter section 5.1.8 (see Figure 24 for an example of a library in a public school). In this exploratory study, lack of contextualised digital learning materials posed as a major challenge to successfully deploy technology to support educational activities.

Figure 24: Library in one of the public schools which mainly offer local newspapers and books of literature (Source: Author)

All the 4 schools involved in this study had better infrastructure than under-resourced rural schools in remote areas. However, even though these schools had a computer lab facility, students and teachers never used it for teaching and learning English and other subjects. Computers were strictly used for teaching computer skills only. During the research study period, most of the time computer rooms were observed either locked or empty. But, even when computers/internet were available, teachers were unable to find and use necessary learning materials.

Due to lack of digital learning resources, there was also no culture of content sharing among the teachers. The technology and infrastructure could only facilitate mobile learning interventions but to appropriate them for enhancing teaching and learning process requires interactive digital content and these schools did not have capacity and resources to develop and test such learning materials.

6.6 Offline digital library

For mobile learning requires effective learning resources that fulfil learning objectives outlined in the curriculum and improve the way teachers teach and students learn. As Nepal's national policies on ICT in education provide nominal direction and support and in practice, there are virtually no state-funded ICT programmes in government schools (Shields, 2011), one way of dealing with this challenge could be working with established organisations running programmes that use ICT in education.

Table 7: The breakdown of the costing per school for one-time e-library installation and orientation (Exchange Rate: £1.00 = NRs 152.85)

Equipment	NRs. 37,000
Travel, Transport, Insurance:	NRs. 6,000
Technical setup & Orientation at schools:	NRs. 28,000
Procurement & installation:	NRs. 5,500
Office overhead:	NRs. 3,500
Overall Cost:	NRs 80,000 (£523.40)

Raven, (2013) critically evaluated a project where a lab of computers was gifted to a poor school in Nepal with the intention of raising the level of technical capital within the community. The remote school did not have any electricity or access to road at that time. Initially, in 2010, the project installed a fully functioning computers. But, in 2013, when a project returned to the school to upgrade the lab, they found the computers were moved to a new building primarily used as the computer teacher's office with no access to students. While two computers seemed to be used regularly, most of the computers did not work and were covered in dust cloths.

Figure 25: Installation of offline server in one of the public school to allow local access to digital library (E-Pustakalaya) (Source: Author)

Thus, in one of the public school, offline digital library (see Figure 25) was setup with the help of OLE Nepal to provide an access to suitable digital learning resources and supplement the exploratory study of using mobile devices for teaching and learning. The funding for this library came from author's friends and family (see Table 7 above). A full payment was made in advance by deposit in OLE's bank account before the installation.

As there were already sixteen computers in the school, the total cost was for buying one machine and few network equipment to get E-Pustakalaya [digital library] running. This included all the hardware equipment, travel costs, on-site installation and network, and orientation to local community members on how to use the digital library. To install the digital library, school and sponsors had to accept the following condition:

"*The school and its staffs respect OLE Nepal's ownership of Epustakalaya and its contents. The school/sponsor agree to acknowledge OLE Nepal for ownership and Nepal Library Foundation (NLF) for support in case of publicity about the Epustakalaya*".

During the deployment of the digital library, school's infrastructure was assessed required for the digital library and the required software was installed in the computers. Then, a computer network was established and the server with the digital library was added to the network. Thus, allowing offline access of the digital library. The networked server is also connected to a router enabling the wireless access for laptop/mobile user.

After the installation, the teachers and selected students representing each class were oriented on how to use the digital library. According to OLE Nepal, they update the offline digital library in every 3 months during the school visits, which simply requires plugging in the USB drive in the library server with the updated version of content and the server automatically updates the repository.

The digital library gave teachers education-focused full-text documents, books, images, videos, audio files, and interactive educational software that could be accessed offline through the Intranet. The use of the materials in the library is governed by Creative Commons 3.0 Attribution-Non Commercial-Share Alike copyright licenses.

In this school, offline digital library allowed teachers to research and identify readily available useful learning materials for teaching and learning. According to teachers, availability of resources positively influenced their motivation to use the technology for facilitating teaching and learning.

Figure 26: School's computer technician helping OLE engineers to network the PCs and teachers training on the use of digital library (Source: Author)

However, to plan ICT incorporation into teaching practices to make it more effective, it is essential to engage teachers to identify the best approach to support them without directly challenging their existing teaching and learning practices. Just the involvement of school's local computer technician in setting up the digital library and the teachers' training on the use of the digital library (see Figure 26) increased the interest in adopting it in their everyday practices. But as the open-source mobile devices evaluated in this research study did not have a simple user-friendly functionality to facilitate transferring digital content, they were unable to make the most of it without a technical support during the study period.

Teachers said they should be able to upload and share useful teaching and learning materials in the school's library and easily access and download in their personal devices such as mobile phones whenever necessary. But they were not interested in preparing teaching activities that would take too much of their valuable time as they were busy teaching maximum number of hours in a week with no time left to do any other activities.

Figure 27: A teacher using his own mobile phone for listening test with a portable speaker. Previously a teacher used to read the text himself. (Source: Author)

One of the visible positive consequences of this study was that taking away the loaned devices at the end of the study period did not deter one of the teachers continuing to use a mobile learning approach to support English language teaching. The teacher used his own mobile phone to record texts or conversations necessary for conducting listening test and played with a portable low-cost Chinese speaker (as seen in Figure 27). He also showed further interest in learning the ways of incorporating mobile phones to support English teaching.

6.7 Conclusions

The focus of this chapter was to evaluate the open-source devices which were used to support teaching English within a well-defined curriculum of class 9 and 10 in the formalised teaching setting of schools in Nepal. The direct users of the devices were the teachers who always played a central role in traditional teaching practices. While these devices provided an offline access to relevant learning resources and helped increase the interaction in the classroom, it once again highlighted the further challenges to develop and sustain mobile learning in the context of public schools of Nepal. They were i) lack of teachers' capacity and schools support to effectively integrate technology in classroom teaching; ii) lack of access to relevant digital educational resources; and iii) identifying feasible and usable mobile devices that are appropriate for supporting teaching and learning. By collaborating with successful grassroots organisations to provide offline digital library and teacher training can increase the access to digital learning resources for teaching and learning. But, to successfully adopt mobile devices in education require appropriate software to easily synchronise digital content and teachers need to be able to use technologies without increasing their workload.

Chapter 7

Discussion of findings

In this final chapter, discussion is based on the findings emerging from the evaluation of users, their needs and their context in the completed exploratory studies. The question for which it attempts to answer relate to the original research questions found in the introduction of this thesis. The question which it attempts to answer is as below:

“What are the challenges of introducing ICT for supporting schools’ education in Nepal and how might we design a sustainable mobile learning solution using open-source platforms?”

The findings are presented as the overall challenges based on the work which the research completed has investigated. It further discusses the three main aspects of this research study.

i. The overall challenges (7.1)
ii. Sustainable mobile learning solution (7.2)
iii. Summary of key outcomes of the research (7.3)

7.1 The overall challenges

Based on the main study, below is the summary of challenges (see Table 8) for providing a sustainable mobile learning solution in the context of schools of a developing country – Nepal. These challenges are central for making mobile learning a reality.

Table 8: Main challenges (Source: Author)

C1	Teachers & teaching techniques
C2	Mobile Platform
C3	The lack of resources
C4	Social divide
C5	Schools divide
C6	The infrastructure
C7	The political instability
C8	Scale & sustain ICT programs

7.1.1 Teachers and teaching techniques (C1)

Teachers are a key in delivering learning, only source and medium of transmitting knowledge in traditional settings of teaching and learning. However, even though teachers play key role in improving learning outcomes, they lack skills and knowledge to apply appropriate teaching and learning techniques in classrooms.

7.1.2 Mobile platform (C2)

Compared to desktop computers and laptops, mobile phone has more realistic adoption possibilities and help both teaching and learning processes. Teachers have access to relatively cheaper mobile technology. But mobile learning outcomes should not be constrained by lack of a high-end smartphones. To deliver and support learning as a key aspect of a sustainable mobile learning solution, the challenge is to consider an appropriate (affordable and flexible) mobile platform before proposing and developing such solution.

Evaluation of Nanonote and Wikireader devices shows limited functionalities and usability issues restrict the usage of the devices and challenge to identify teaching and learning opportunities that could engage teachers and students and enrich learning process. It is far more important to provide easy to access contextualised learning activities that are engaging and the benefits that are obvious from the start.

In resource-constrained environments of public schools where student-to-teacher ratio is very high and student-to-computer ratio is either very high or ICT is non-existent, 1:1 use of technology to provide a better level of access is also practically impossible.

7.1.3 The lack of resources (C3)

The lack of teaching materials in local and English languages in public schools is one of the major problems and poor students cannot afford to buy educational materials as well. As the education is still text-book oriented and dependent on teachers to deliver, it makes challenging to change the traditional methods of teaching and learning and provide a suitable learning environment. Due to lack of digital learning resources and knowledge of mobile learning techniques, use of mobile for educational purposes is hard to achieve as well. Without an access to interactive digital content, providing technology and establishing the necessary infrastructure cannot enhance teaching and learning process. Public schools do not have a capacity and resources to develop and test such learning materials.

Even when Internet access is available, it is important to consider the cost of its use and data downloading, availability of Wi-Fi in the classrooms, speed/security/privacy issues and the features and capabilities of various type of mobile devices used.

7.1.4 Social divide (C4)

The gender discrimination, caste and ethnicity-based social stratification of Nepal has shaped the deep rooted social divide and plays its part in Nepal's culture, tradition, politics, and increasing the disparity in rural and urban areas, rich and poor.

7.1.5 Schools divide (C5)

In Nepal, one of the poorest countries in the world, profit-oriented private schools, which have expensive fee structure, and books that the poor cannot afford, are becoming privilege for families of higher socio-economic status whereas most of the students in a government school belong to poor families and underprivileged/marginalized group, backwards and schedule casts. This schools divide is further deepening the social inequality that already exists.

7.1.6 The infrastructure (C6)

Under-resourced schools are unable to invest on technological solutions. Schools have other pressing needs such as lack of trained teachers, well-facilitated classrooms, electricity and clean water supply. Therefore, regardless of proliferation of mobile phones and use in the community, mobile learning is not yet prevalent in Nepal's education system.

7.1.7 The political instability (C7)

After years of civil war, Nepal is still suffering due to a political instability and weak governance, and there is no certainty when this transition phase will end. In Nepal public schools' education, political instability has the negative impact.

7.1.8 Scale and sustain ICT programs (C8)

ICT initiatives often encounter problems of scale-up and sustainability in developing countries as schools are unable to build and maintain the required supporting infrastructure and lack local capacities. Hence, developing a simple but cost-effective and sustainable solution is a tremendous challenge.

7.2 Sustainable mobile learning solution

This research has investigated the challenges to implement a sustainable mobile learning solution that could engage with educational practices in the context of public schools of Nepal. The study also evaluated potential benefits and limitations of using low-cost open-source mobile devices.

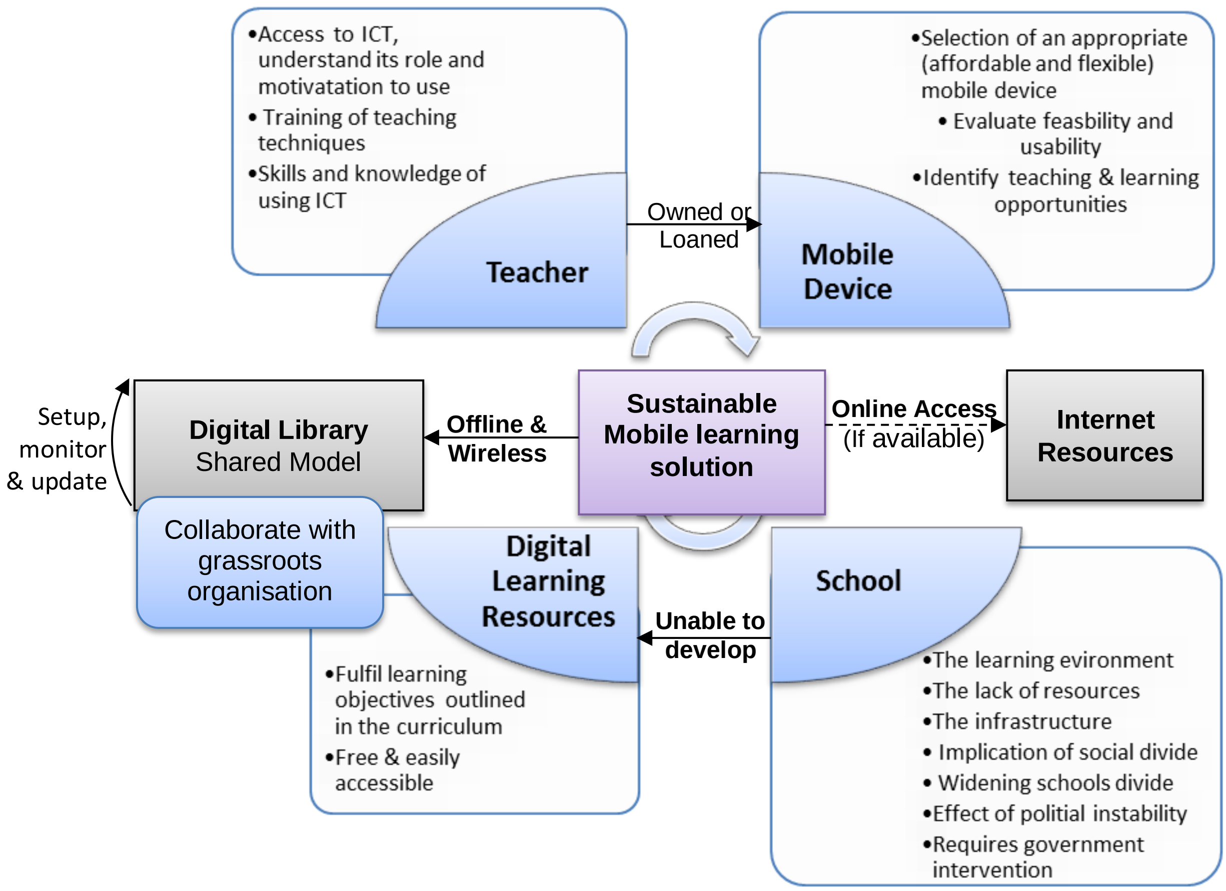


Figure 28: Designing a locally relevant sustainable mobile learning solution and making the same quality education accessible for all schools of Nepal. (Source: Author)

Realising the potential of mobile learning is indeed a complex endeavour (Carly *et al.*, 2013). However, it may be possible to achieve a locally relevant sustainable mobile learning solution in an under-resourced environment by addressing the challenges (see Table 8, section 7.1) and following the model (see Figure 28 above) which is an outcome based on the realities and limitations of existing education, ICT infrastructure and the social and cultural context. This model has a four main components (as identified in section 2.11) and addresses the overall challenges discussed in the section above.

7.2.1 Teacher

This model recognises a teacher's role is a key to deliver child-centric interactive learning. In formal education of schools' of Nepal, teachers play primary role in improving student's learning and reduce educational inequalities. Mobile learning led by an effective pedagogy with teachers access to ICT, understanding its role and motivation to use; skills and knowledge of using ICT and training to embed technology enhanced learning into their everyday educational practices are fundamental**.** But, "teacher education programs in Nepal have often been criticized for not sufficiently addressing the needs of the diverse country which hosts more than 120 linguistic and cultural groups. Oftentimes, it has been pointed out that teacher education curricula borrow readymade pedagogical models from the developed world without considering their appropriateness in Nepali classroom contexts" (Pangeni, 2016, p.34). As mobile learning lies in taking advantage of the learning opportunities offered by mobile technologies, it requires teacher training that cover custom designed mobile pedagogy that fits into the existing cultural practices as well as some technical training to build confidence (UNESCO, 2010). **[Links to C1: Teachers and teaching techniques]**

7.2.2 Mobile device

A good quality education depends on a curriculum that is relevant and inclusive; an effective and appropriate pedagogical approach; the use of children's mother tongues; and the use of appropriate technology (UNESCO, 2015) and mobile devices offer a relatively inexpensive way to support digital learning (UNESCO, 2010). Mobile phones are rapidly becoming more and more embedded in the society and the introduction of technology into classroom can help both teaching and learning process. Selection of an appropriate (affordable and flexible) mobile device for mobile learning may consider teachers' owned or loaning devices considering the benefits and disadvantages of both approaches. But, it is vital to evaluate its feasibility and usability and identify teaching and learning opportunities using those devices in that particular context. To introduce a new technology into mainstream schooling to transform teaching and learning across the curriculum is extremely challenging as well. Where one to one use of technology to provide a better level of access is practically impossible, *shared model* could be implemented as a cost savings approach to sustain the use of technological platforms in schools. **[Links to C2: Mobile platform]**

7.2.3 Digital learning resources

The success of teaching and learning is linked to available resources, in developing countries availability of textbooks remains severely limited (UNESCO, 2015). Mobile learning solutions can address the issue of lack of learning resources. While technology provides the medium to deliver quality education, it requires free and easily accessible digital learning resources (in English and local languages) that fulfil learning objectives outlined in the curriculum and improve the way teachers teach and students learn. Design of successful mobile learning solution must consider providing access to relevant digital resources (*offline*) without relying on unreliable, slow and expensive Internet access as well. Applications have more chances of being used/supported and sustained if they supplement existing solutions. For example, an offline digital library can be deployed with shared model approach to offer an equal access to teachers and students. Then, a mobile application could interface this library to provide offline access to the learning resources and activities from the local server and where available, anytime access using internet. It could make library more accessible and enhance its usage. **[Links to C3: The lack of resources]**

7.2.4 Schools

Schools need to provide teaching resources, training and support to create the technology enhanced learning environment to support education through mobile technology-based innovation but schools are unable to build and maintain the required supporting infrastructure and lack local capacities. The schools' lack of resources/infrastructure and a learning environment; the increasing gap between public/private schools and the implications of social divide; the political instability and its unnecessary influences hinder exploring such ICT enabled educational opportunities. For mobile learning to be sustainable requires government's intervention to tackle these serious challenges that schools face.

Nepal's government intervention is necessary to address the significant challenge that the education system faces to make sure quality education is accessible to all. Cost-effective mobile-based learning solutions may help address this serious issue by providing alternative methods of access to the quality education for poor majority**. [Links to C4 & C5: Social divide and Schools divide]**

“The political volatility in the country has demonstrably affected the schooling sector” (Joshi, 2014, p.59). “The Nepalese government needs to create an educational system that is free of political meddling and nepotism” (Neupane, 2014, p.169). It needs to tackle the biggest challenge of establishing the proper information infrastructure and formulate a clear policy about establishing the transparent educational environment, allocation of resources and ways to improve the education. However, it is unlikely that a recommendation in a PhD thesis is likely to make an impact on government. **[Links to C6 & C7: The infrastructure and The political instability]**

There are no state-funded ICT programmes in government schools. Therefore, to implement ICT initiatives in schools, it is essential to *collaborate* with successful local organisations. Otherwise, such projects do not succeed.

To adopt and integrate a mobile learning into an existing teaching and learning practices, it is crucial to co-design mobile learning programmes with communities to best address their specific needs (Carly *et al.*, 2013) and local support with training leading to taking full ownership is required to fully embed the technology into education activities in schools (Raven, 2013). For example, OLE Nepal can help introduce an ICT-based education approach in Nepali public schools which works in conjunction with the government. Similarly, not-for-profit making initiatives NWNP can help establish communication infrastructure which has so far connected more than 175 remote villages in 15 districts of Nepal. **[Links to C8: Scale & sustain ICT programs]**

With a clear understanding of educational requirements and the context; working closely with schools, teachers and students, local education/technology experts, grassroots organisations, government and a community, simple but locally targeted mobile learning solutions can be developed for under-resourced rural public schools of Nepal to provide an equal access to useful digital resources and education.

7.3 Summary of key outcomes of the research

The further discussions of the three main aspects of this research based on the challenges identified from this research study.

7.3.1 Assessment of open-source technology

For mobile learning in developing countries, cost is still a relevant factor as readily available devices lack high-end capabilities and high-end devices are not readily available yet. With the reducing hardware cost and wider adoption of open-source platforms, it is hoped that the possibility of offering sustainable services in the future will increase. The chapters 4 and 6 demonstrated the use of such devices Nanonote and Wikireader to support offline mobile learning and identified benefits, limitations and implication of introducing these devices.

Even though open-source platforms provide the greater flexibility and freedom that can be leveraged to shape the design of future cost-effective and sustainable mobile learning solutions that users really need, the studies show it is also critical to provide a satisfactory user experience at the same level or else effectiveness of using such devices cannot be realised and the solution is more likely to fail.

From the results of this evaluation, the main aim was not to ascertain whether or not Wikireader and Nanonote devices can improve learning. The finding shows there are significant development difficulties including usability issues and the lack of a standard graphical user interface. It is a challenge to develop a custom software and content to fully appreciate the potential of these devices. However, using its offline, audio/video capabilities, these open-source devices demonstrated a potential to implement a simple mobile learning intervention which could facilitate the student-centred approach in language teaching and learning. Therefore, for any chance mobile devices to be used in such challenging learning contexts, the need is to develop simple and innovative solutions, train teachers to embed technology in education and provide access to relevant digital content.

7.3.2 The role of mobile learning Interventions in developing countries

The work undertaken in this thesis has tried to identify overall challenges to teaching and learning in public schools of Nepal and further enforces the challenges of introducing technology in under-resourced schools. Beyond technical challenges, in an ethnically and socio-culturally diverse Nepalese society, education system faces more significant challenges to improve and therefore technological interventions must be designed with a social responsibility.

Nepal's topography is such that it increases the disparity in rural and urban areas, rich and poor. It is extremely difficult to develop the much-needed infrastructure and provide resources to support schools, especially in rural area where the majority of the schools are located. Many public schools are unable to spend the limited funding received from the government for any other activities (MOE, 2008). Private schools are generally located in urban areas and better resourced. They are performance oriented and comparatively produce better results. However, they are inaccessible and charge higher tuition fees unaffordable for the majority of poor Nepalese citizens. The unresolved political crisis in the country and the lack of government's initiatives to develop the equally accessible education system for all is rather worsening the divide between the 'advantaged' and the 'disadvantaged' in Nepal.

There are evidences from microcredit programs designed to serve the bottom of the pyramid (BoP) which show ignoring effects of forms of social stratification within societies actually reinforce the structural inequalities (Ilahiane and Sherry, 2012). This study provided some evidences, which show the increase in disparities in public and private schools and its impact is also increasing the divide in Nepal's education and society. Due to lack of focus on tackling the political, pedagogical, social and cultural issues, the 'school divide' is increasing and fuelling the 'social divide' that already exists in an ethnically and socio-culturally diverse Nepalese society.

The clear need is for the state's interventions to influence these issues, strong policies to improve the public schools, manage and monitor private schools, and ensure everybody receives opportunities for better education. Though ICT may not directly help remove these issues, local targeted ICT for education initiatives should aim to actively involve public schools. In Nepal, though there is no significant, visible impact from the limited use of technology (XO laptops) based solution, teachers agree that integrating technology in education has provided the access to same high quality educational resources even in remote rural under-resourced schools and is somehow helping to reduce the disparities in the education sector.

Even though there are opportunities and possibilities to enhance learning by incorporating technology in the existing educational process, the challenges are to develop a sustainable solution with the bottom-up understanding of these challenges and embed into the learning context and to deploy, support and sustain a mobile learning solution itself will not be a trivial task.

7.3.3 Offline mobile learning: why and how?

In Nepal's context, it is important to design applications that completely do not depend on the availability of wireless network, internet connectivity and expensive smart devices and provide online/offline ready access to learning resources in a challenging environment. It may be possible to develop a simple technical solution, an offline mobile learning solution using a low-cost mobile technology that might be sustainable, scalable and work.

Regardless of increasing penetration of mobile phones, repurposing cheap existing mobile phones are not easy and there is a very low penetration of highly subsidised smart devices. Internet connectivity is also nearly non-existent. The Department of Education of Nepal has also banned mobile phones on school premises 'to maintain order' and mobiles are also banned in higher secondary school premises according to a Code of Conduct published by the Higher Secondary Education Board (HSEB) in 2013. Schools may not be able to sustain this approach of forbidding use of mobile phones and other devices in schools' premises (UNESCO, 2010), but for the time being adopting offline mobile learning model could eliminate these concerns as this study shows lack of internet connection was not a limitation to learning. It can help shift the resistance by highlighting the benefits of mobile learning and promote the use of mobile device in the education community.

Chapter 8

Conclusion: contribution, limitations and future works

This chapter concludes highlighting the contributions to the field of study, limitations of the research, future work and directions.

8.1 Contribution of the thesis

This thesis makes a contribution to an understanding of the holistic view of mobile learning and sustainability by identifying the challenges of designing a mobile learning solution based on the thorough understanding of the educational context of Nepal and evaluation of capabilities the open-source mobile devices offer. This research offers the following contribution to the field of mobile learning:

The first contribution, which the work undertaken in this thesis dissertation describes, is a novel use of open-source mobile devices in the context of teaching and learning programming and benefits of hand-on practices without being restricted to the institutional contexts, as noted in chapter 4. The research recommends further explorations of these devices to develop an effective and sustainable offline mobile learning solution to provide ready access to educational resources.

The second contribution from the study of Nepal's schools' education system is it highlights the increase in disparities in public and private schools and its impact on increasing the divide in Nepal's education and society. But to translate the understanding of these challenges to a design of a sustainable mobile learning solution is a complex challenge. Mobile learning can only ensure the equal access to quality education.

Researchers have evaluated mobile learning solutions in the various learning contexts of developing world. The third contribution emerges from the study of XO laptops used in under-resourced public schools which describes limited success of this project due to major challenges of scalability and sustainability and highlights the benefits of fit for the purpose offline digital library for supporting teaching and learning.

A first study of its kind, the exploratory study of Wikireader and Nanonote devices extends the body of knowledge about the use of open-source platforms in the challenging context of schools of Nepal which gave an opportunity for teachers to engage in offline mobile learning. Though these devices were technically challenging, teachers were still able to identify an opportunity to support listening element of English language teaching and learning.

A larger contribution is a suggestion for designing a locally relevant sustainable mobile learning solution to provide the same quality education accessible in schools of Nepal by addressing overall challenges identified in this study.

8.2 Limitations of the research

This thesis drew on, and contributed to research fields of mobile learning in the context of information communication technology for development and education (ICT4D & ICT4ED). This exploratory study is not an attempt to understand the relationship of ICT with much-disputed issues of development. It has however helped to focus on the social dimension of mobile learning. Therefore, this study evaluated the low-cost open-source devices to identify its benefits and limitations with the focus on various challenges that influence the sustainability of a mobile learning solution. Software and content were customised or updated as necessary but design and implementation of new software applications and hardware related technical aspects and development was also out of this research scope.

Participants for the main study in Nepal were only schools' teachers. The aim of this study was not to identify and measure the impact on student's' learning and also not meant for generalising the findings to a larger population due to small number of participations in a short period of the study. The findings of this study were specific to the research setting and should be used with caution to inform other education related studies.

This study mainly focused on better understanding the context; identify the challenges and opportunities and the best possible approach for mobile learning specific to that context. The results may be useful to design a future sustainable mobile learning solution to provide an access to educational materials and support learning in similar contexts. Even though ICT may meet educational needs, to identify whether it could bring change to formal education in Nepal is out of the scope of this research study.

8.3 Future work and directions

The following is the suggestion for future research on the area of implementing mobile learning in the context of Nepal:

This study was conducted to understand the challenging educational context of schools of Nepal and evaluate the open-source devices for a short period, as it was a part of a doctoral study program with prefixed deadlines. Using new or existing technologies, this research could help explore the novel and cost-effective approaches to provide a much-needed access to digital resources and supplement the teaching and learning practices. Future research work with an extended field-based evaluation of how such devices can be used to support education in different contexts and address challenges identified in these studies could add significant value to the generalizability of the research.

In the process of demonstrating the feasibility of the mobile devices and the mobile learning approach used, the further carefully designed longitudinal research studies could identify the possible ways of introducing mobile learning in a resources-constrained environment and recommend ways to scale and sustain it.

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Appendix A: Equipment Allocation Agreement

Equipment Allocation Agreement 2010.001

School of Computing and Technology

The item listed below is being allocated to you as requested.

Device Type	Description	Serial	Asset	You have
Nanonote	An ultra-small form factor computing device	n/a	47989	
Nanonote	An ultra-small form factor computing device	n/a	47990	
Nanonote	An ultra-small form factor computing device	n/a	47991	
Nanonote	An ultra-small form factor computing device	n/a	47992	
Nanonote	An ultra-small form factor computing device	n/a	47993	
Nanonote	An ultra-small form factor computing device	n/a	-	
WikiReader	Wikipedia offline	2917900416	47994	
WikiReader	Wikipedia offline	2917900125	47995	
WikiReader	Wikipedia offline	2917900135	47996	
WikiReader	Wikipedia offline	2917900287	47997	
WikiReader	Wikipedia offline	2917900419	47998	
WikiReader	Wikipedia offline	2917900421	47999	

Terms and Conditions:

1. The device will be your responsibility.
2. The device will be handled with care and carried in a suitable manner so as to avoid any possible damage.
3. When not in use, the device will be locked away in a secure location (out of sight).
4. The device will be returned to Sujan Shrestha or John Moore at the end of the loan period or upon leaving the University whichever is the earlier.
5. Sujan Shrestha or John Moore have the right to recall device if the terms of this allocation are breached.
6. Sujan Shrestha or John Moore also has the right to check the device at any item during the borrowing period.

If you agree to these terms and conditions, then please sign below.

Authorized by John Moore ________________ Date: ________________

The device is to be returned by: Date: ________________

I agree to the above terms and conditions. (Signed) ________________

Appendix B: Evaluation Study Logbook

Wikireader / Nanonote Evaluation study: Logbook

When?	Where?	Why?	Useful?	Problems or difficulties?

Name:________________________________ Student ID: ______________

Appendix C: Pre-test Questionnaire

Pre-test Questionnaire: Developmental study and Main study

1. Gender: Male [ ] Female [ ]

2. What age group do you belong to?
(Please tick in the appropriate box)

Under 18	
18 – 25	
26 - 35	
36 - 45	
46 - 65	
Over 65	

<u>Using desktop computer</u>

3. Do you have an access to computer?

[ ] Yes [ ] No (go to question 10)

4. I have an access to computer at:

[ ] Home [ ] Library [ ] Other ….................................
(please specify)

5. My desktop computer experience is:

[ ] Low [ ] Average [ ] High

6. How often do you use the computer?

[ ] Almost Everyday
[ ] 2-3 times a week
[ ] Once a week
[ ] Less than once a week

7. Do you use the computer primarily for . . ? (please tick all that apply)
[ ] Personal use [ ] Work use [ ] Study

8. Do you have an access to Internet while using the computer?
[ ] Yes [ ] No (go to question 10)

9. How often do you use the Internet?

[ ] Almost Everyday
[ ] 2-3 times a week
[ ] Once a week
[ ] Less than once a week

Using mobile device

10. Do you own or have an access to mobile device?
[ ] Yes
[ ] No (go to question 18)

11. How much experience of using mobile phone do you have?

[ ] A Little [ ] Average [ ] A Lot

12. What kind of mobile phone do you currently use?

Make:
[ ] Sony Ericsson
[ ] Nokia
[ ] Samsung
[ ] Motorola
[ ] iPhone
[ ] Other
…..
(please specify)

Model:
....
(please specify)

13. My phone is: [ ] Pre-Paid (pay as you go) [ ] Post-Paid (contract)

Does it include unlimited data usages? [ ] Yes [ ] No.

14. I use mobile phone for ..?

15. Do you use the phone to browse the web?

[ ] Yes [ ] No (go to question 18)

16. If answer 'Yes' to question 15, how often?

[ ] Almost Everyday
[ ] 2-3 times a week
[ ] Once a week
[ ] Less than once a week

17. I use mobile Internet for ..?

18. If you answer 'No' to question 10 or 15, please specify the reason why?

Appendix D: Post-test Questionnaire - Wikireader

Post-test questionnaire: Evaluation of Wikireader

(Developmental study & sub-study 3)

The following questions relate to your opinions about **Wikireader**.

Using the **Wikireader**

1. How often did you use the Wikireader?

(Please tick the appropriate box)

	Less than once a week
	Once a week
	A few days a week
	Every day
	Did not use

2. When did you use the Wikireader?
(Please tick all that apply)

[ ] At home
[ ] At library
[ ] At work
[ ] While travelling
[ ] Other …..
(please specify)

Reading on the **Wikireader**

The following questions are about how easy or difficult it is to read on the Wikireader.

3. How easy/difficult is it to read on the Wikireader?
(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy
	Did not read on the Wikireader

4. Why was it **<u>easy</u>** to read on the Wikireader?

5. Why was it **<u>difficult</u>** to read on the Wikireader?

6. For how long can you comfortably read from the screen of the Wikireader?

(Please tick the appropriate box)

	A few minutes
	Up to half an hour
	Up to an hour
	More than an hour

7. When reading course materials on the Wikireader, did you write notes on paper?

(Please tick the appropriate box)

	Never
	Sometimes
	Frequently

8. When using the Wikireader to read materials, did you use the "search" feature?

[ ] Yes
[ ] No

9. How easy/difficult was it to use "search"?

(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy
	Did not search

10. How easy/difficult was it to use the onscreen keyboard?

(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy

11. How useful is the "random" feature?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful
	Did not use

12. How useful is the "history" feature?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful
	Did not use

13. How useful was the Wikireader for reading?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful

14. What was the main **benefit** of using the Wikireader to read?

15. What was the main **limitation** of using the Wikireader to read?

16. Did you use any other features of the Wikireader? (please specify)

17. Do you prefer to read on..
(Please tick the appropriate box)

	On the Wikireader?
	On the Computer?
	On Paper?

General perceptions of the **Wikireader**

18. Overall, how useful was the Wikireader?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful

19. What were the general **benefits** of using the Wikireader?

20. What were the general **limitations** of using the Wikireader?

21. Did you feel that you need technical support and training to use the Wikireader?

[ ] Yes
[ ] No

If '**Yes**', what support do you need?

22. What other comments do you have about your experience of using the Wikireader?

We will ensure all your responses remain anonymous.

Thank you for taking the time to complete this questionnaire.

Your participation is very much appreciated!

The following questions relate to your opinions about **Ben Nanonote**.

Appendix E: Post-test Questionnaire - Nanonote

Post-test questionnaire: Evaluation of Nanonote

(Developmental study & sub-study 3)

Using the **Nanonote**

1. How often did you use the Nanonote?
(Please tick the appropriate box)

	Less than once a week
	Once a week
	A few days a week
	Every day
	Did not use

2. When did you use the Nanonote?
(Please tick all that apply)

[ ] At home
[ ] At library
[ ] At work
[ ] While travelling
[ ] Other …..
(please specify)

Reading on the **Nanonote**

The following questions are about how easy or difficult it is to read on the Nanonote.

3. How easy/difficult is it to read on the Nanonote?
(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy
	Did not read on the Nanonote

4. Why was it **easy** to read on the Nanonote?

5. Why was it **difficult** to read on the Nanonote?

6. For how long can you comfortably read from the screen of the Nanonote?
(Please tick the appropriate box)

	A few minutes
	Up to half an hour
	Up to an hour
	More than an hour

7. When reading course materials on the Nanonote, did you write notes on paper?
(Please tick the appropriate box)

	Never
	Sometimes
	Frequently

8. When using the Nanonote to read materials, did you use the "search" feature?

[ ] Yes
[ ] No

9. How easy/difficult was it to use "search"?
(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy
	Did not search

10. How easy/difficult was it to use the keyboard?
(Please tick the appropriate box)

	Very difficult
	Somewhat difficult
	Neither easy nor difficult
	Rather easy
	Very easy

11. How useful was the Nanonote for reading?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful

12. What was the main **benefit** of using the Nanonote to read?

13. What was the main **limitation** of using the Nanonote to read?

14. Did you use any other features of the Nanonote? (please specify)

15. Do you prefer to read on..
(Please tick the appropriate box)

	On the Nanonote?
	On the Computer?
	On Paper?

<u>General perceptions of the **Nanonote**</u>

16. Overall, how useful was the Nanonote?
(Please tick the appropriate box)

	Not useful
	Somewhat useful
	Very useful

17. What were the general **<u>benefits</u>** of using the Nanonote?

18. What were the general **<u>limitations</u>** of using the Nanonote?

19. Did you feel that you need technical support and training to use the Nanonote?

[ ] Yes
[ ] No
If '**Yes**', what support do you need?

20. What other comments do you have about your experience of using the Nanonote?

We will ensure all your responses remain anonymous.

Thank you for taking the time to complete this questionnaire.

<u>Your participation is very much appreciated!</u>

Appendix F: Informed Consent

Main study in Nepal

Informed Consent

Title of Research: "EXPLORING MOBILE LEARNING OPPORTUNITIES IN NEPAL: THE POTENTIAL OF OPEN-SOURCE PLATFORMS"

Investigator: My name is Sujan Shrestha. I am a student of School of Computing, Faculty of Professional Studies, University of West London, UK.

Introduction: Poor information infrastructure and higher costs of mobile devices and connectivity restrict possibilities of providing successful mobile learning (mLearning) services. Therefore, my research aim is to explore and identify an affordable and sustainable mobile learning solution using low-cost mobile technology and without requiring to access Internet in the context of schools that use traditional teaching practices in Nepal.

Explanation of Procedure: You are being requested to participate in the initial stage of this research project. The approach of the research is through the use of questionnaires. At first, the questionnaire has been designed to obtain information about you, your desktop computer and mobile experience. Next, it aims to collect further information about you and your school, issues of infrastructure and access to ICT, current English teaching practices and identify technological needs. Please write down your thoughts which are relevant to you at any given moment.

Benefits: There are no direct benefits by participating in this initial exploratory study. However, this research is expected to provide a deeper understanding of existing teaching strategies, how you structure, teach and deliver learning, the difficulties, what is important to you and to ascertain your preconceptions about the mobile device, what could be the motivation to adopt a mobile device and your expectations of how useful it would be in the context of teaching and learning.

Confidentiality: All of the information obtained from this study will be kept confidential. All the data collected for this work will be presented in future publication anonymously. If you have any question relating to the study please do not hesitate to ask me.

Agreement: The consent form just says that you understand what this study is about, that you understand I will respect your privacy wishes, and that you will allow me to publish any results from this study. This agreement states that you have received a copy of this informed consent.

Finally, I would like to thank you for agreeing to provide your valuable feedback.

Your Name: ....

Your contact details: ….. (optional)

Your email: .... (optional)

(Please note this information is required to match responses. New ID codes will be generated to ensure your responses remain anonymous)

Please read through the questions below, and tick as appropriate:
I have read and understood the information sheet................................... [ ]Yes [ ]No
I am free to change my mind and withdraw from this study at any time..[ ]Yes [ ]No
I am willing to help this research by participating in this research study..[ ]Yes [ ]No
On this basis I agree to participate.

Participant Signature...
Date..
(Please sign or type your name)

Appendix G: About you and your school

Schools with limited or no access to ICT: Sub-study 1

About You and Your School

1. What is the name of your school and the address?
2. Where were you born? (example: Naryangarh, Pokhara)
3. What is your native language? (example: Nepali)
4. What other languages do you speak/understand? (e.g. Newari, Gurung, Hindi, English)
5. Do you do any paid or unpaid work before or after school?
6. How long does it take to come to school? (example: 15mins, ½ an hour, 1 hour)
7. In your opinion, what are the general **problems** in your school?
8. From your point of view, what is the difference between public and private boarding schools?
9. What more needs to be taught in school (in your opinion, what is still missing)?
10. In your opinion, how is the teaching/learning practice (maybe) different in your school from others?
11. What do you know about the place where you study, the culture, customs, traditions etc.? Tell me all the places, people, events of the community where you learn **cultural knowledge**, about their traditions, costumes etc. - where do you learn practical knowledge?
12. How is your relation to the parents?

English Teaching in Your School

1. Why it is important to teach English? How do you value learning English?
2. Do you have interactions with English speakers outside school?
3. How does your teacher support you to encourage and guide through lessons, clarify doubts or monitor your homework?
4. Do you take extra English tuition outside school? If you do, why?

Infrastructure and Access to ICT

1. What are the issues related to the availability of 'Electricity'? How does it affect you?
2. Does your school provide extra help with learning resources/text books?
3. Is there a library in your school? Are there useful resources for teaching and learning English?
4. Do you have access to computer in the school or outside such as public library and home?
5. Are computer lessons part of the curriculum in your school? **If they are, can you provide an insight into how the computer lessons are being conducted?**
6. Do you have basic knowledge of using information communication technology (ICT)?

Use of ICT in classroom: Identifying Technological Need

1. Do you think mobile phone & other portable devices will be useful to study English?

2. Do you think the introduction of mobile technology into classroom will help you & teachers?

3. In your opinion, how can a computer/mobile technology facilitate you to learn better **English**?

4. Can you please highlight what type of resources will be useful for learning English?

5. Do you use any other type of information/resources except text-books to study English?

6. If there was a device to help you prepare lessons what content would you like it to have?

We will ensure all your responses remain *anonymous*. Thank you for taking the time to complete this questionnaire.

Appendix H: Use of XO laptop in classroom

Use of XO Laptop in classroom: Sub-study 2

1. How would you rate your experience of using XO Laptop?

Not satisfied Satisfied Very good Excellent

Briefly explain, what you like or do not like XO laptop:

2. The OLPC program has been criticized for no sharing policy, no seamless integration with the existing education system, creating resource imbalances and also for its top-down design. What is your experience and view on that?

3. How do you rate the success of XO laptop?

Not successful Partly successful Successful

Briefly explain why you think this:

4. How would you rate the media coverage that OLPC received?

Negative Neutral Positive

Briefly explain why you think this:

5. Is XO sustainable & scalable solution? How is it competing in the market?

6. Are there software/hardware licensing issues?

7. If you had to change anything about XO laptop, what would it be how it would improve?

8.Did you participate in a training course for the XO laptops? When, Where & How Long?

9. What were the issues you encountered while learning to use the XO laptop?

10. What needs to be taught in the next training course?

11. What do the children learn with the XO laptop (what can they learn in your opinion)?

12. What resources, materials, or programs would you like to have inside the XO laptop?

13. How do you use the laptop in class (if you don't use it yet, imagine how you would use it in the future)? How often do you use?

14. What activities do you use and what for (your favourites)?

15.Do you think owning a laptop is good for children's intellectual growth?

Yes No

Final Comments:

Appendix I: Letter from the UWL

Letter from the University authorising number of devices taken to Nepal for the research study

UNIVERSITY OF
WEST LONDON

Faculty of Professional Studies
University of West London
St. Mary's Road
Ealing
London W5 5RF

4 May 2011

TO WHOM IT MAY CONCERN

This is to confirm that Sujan Shrestha is a research student at the University of West London.

He is travelling to Nepal to undertake some research in the area of mobile e-learning with a special emphasis on meeting the needs of Nepalese people in remote areas.

In order to conduct this work he is bringing some portable mobile devices owned by the University of West London. He will be bringing these back to the UK after he has completed his work.

Device Type	Description	Serial #	Asset #
NanoNote	computing device	n/a	47989
NanoNote	computing device	n/a	47990
NanoNote	computing device	n/a	47991
NanoNote	computing device	n/a	47993
WikiReader	Wikipedia Offline	2917900416	47994
WikiReader	Wikipedia Offline	2917900125	47995
WikiReader	Wikipedia Offline	2917900135	47996
WikiReader	Wikipedia Offline	2917900287	47997
WikiReader	Wikipedia Offline	2917900419	47998
WikiReader	Wikipedia Offline	2917900421	47999

Thank you for your support.

Yours faithfully

Professor Andy Smith
Head, School of Computing and Technology Associate Dean (Research and Enterprise)
Email: andy.smith@uwl.ac.uk
Tel: 020 8280 0256
Fax 020 8280 0259

AS 5-05-11

St Mary's Road, Ealing, London W5 5RF

Appendix J: Research Ethics Consent Form

Research Ethics Consent Form

University of West London
Faculty of Professional Studies
UK Developmental Study

Title of Project: "EXPLORING MOBILE LEARNING OPPORTUNITIES IN NEPAL: THE POTENTIAL OF OPEN-SOURCE PLATFORMS"

Name of Lead Investigators: Sujan Shrestha, Dr. John Moore, Dr.José Abdelnour Nocera

Please initial box

1. I confirm that I have read and understand the information sheet dated .... for the above study and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

Name of Participant	Date	Signature
Name of Person taking consent (if different from researcher)	Date	Signature
Researcher	Date	Signature

Appendix K: Participant Information Sheet

Research Ethics Participant Information Sheet

University of West London
Faculty of Professional Studies
UK Developmental Study

1) Wikireader/Nanonote Evaluation (17/11/2010 – 29/12/2010)

You are being invited to take part in an evaluation of open-source devices (Wikireader and Nanonote) for offline mobile learning. Before you decide it is important for you to understand why the evaluation is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

2) What is the purpose of the study?

The aim of this evaluation is to explore the use of Wikireader and Nanonote devices as a potential mobile learning tool to provide affordable and sustainable offline mobile learning platform.

3) Why have I been chosen?

You have been asked to participate because you are currently studying Mobile Application Development module as a part of the MSc Mobile and Networking course. We will provide learning materials on these devices. As these devices provide an offline access to resources, it will allow anytime and anywhere access and use it to support your study. There are no costs involved to access the content.

4) Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

5) What will I be asked to do if I take part?

You are being requested to participate in this developmental study. The approach of the research is through the use of a questionnaire and a reflective diary. At first, the questionnaire has been designed to obtain information about you, your desktop computer and mobile experience. Then, you are given a Wikireader or Nanonote device for 6 weeks period. Also, you are provided a diary and a pen to enable you to self-report your experience of using the device. Also, please feel free to write down your thoughts which are relevant to you at any given moment, specially focussing on below questions:

- **When did you use the device for a specific purpose for the first time?**
- **When did you find the device particularly useful?**
- **When did you find specific problems or difficulties with using the device?**

6) What will happen to the results of the research study?

The result of this evaluation study will provide a better understanding of use of open-source low-cost hardware for mobile learning, what could be the motivation to adopt such mobile devices and your expectations of how useful it would be in the context of learning.

All of the information obtained from this study will be kept confidential. All the data collected for this work will be presented in future publication anonymously. If you have any question relating to the study, please do not hesitate to ask me.

7) Who is organising and funding the research?

The evaluation is being supported by the Technology Enhanced Learning (TEL) project funded by the Institute for Teaching, Innovation and Learning (INSTIL) at Thames Valley University (TVU).

8) Who has reviewed the study?

This study has been reviewed by the Faculty of Professional Studies Research Review Committee.

9) Contact for Further Information

If you would like any further information please contact any one of the Lead Research Co-ordinators listed below:

Sujan Shrestha, sujan.shrestha@uwl.ac.uk Room TC357, Ealing Campus, St Mary's Road, W5 5RF

If you have any complaints about the conduct of this research project and you wish to discuss them with someone other than the researchers, please contact:

John Moore, moorejo@uwl.ac.uk, Ealing Campus, St Mary's Road, W5 5RF
José Abdelnour Nocera jose.abdelnour-nocera@uwl.ac.uk**, Ealing Campus, St Mary's Road, W5 5RF**

Thank you for your time.

Appendix L: Approval Form

Research Ethics Approval Form

University of West London
Faculty of Professional Studies

Information

All applications for Ethical Approval should be submitted to the Faculty Research Scrutiny and Ethics Committee on this form which outlines a list of issues which should be addressed by the research supervisor / investigator. Applications should be submitted format to chris.kiely@uwl.ac.uk. Copies of participant information sheets, consent forms, questionnaires, adverts, must be submitted with the form.

PROJECT TITLE:	"EXPLORING MOBILE LEARNING OPPORTUNITIES AND CHALLENGES IN NEPAL: THE POTENTIAL OF OPEN-SOURCE PLATFORMS"

THIS PROJECT IS:		Externally funded research projects
(tick as many as apply)		Individual staff research activity
		*MPhil / PhD project work
		MSc / BSc student project work

If externally funded please give details

PRINCIPAL INVESTIGATOR:

TITLE & NAME	POST	FACULTY	PHONE	EMAIL
Mr Sujan Shrestha	Student	FOPS		shresuj@uwl.ac.uk

DECLARATION BY INVESTIGATORS

The information given is, to the best of my knowledge and belief, accurate. I have read the University's Code of Research Practice and accept responsibility for the conduct of the procedures set out in the attached application in accordance with the guidelines, the University's Code of Practice and any other condition laid down Faculty of Professional Studies Research Scrutiny and Ethics Committee. I have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my obligations and the rights of the participants. I and my co-investigators or supporting staff have the appropriate qualifications, experience and facilities to conduct the research set out in the attached application and to deal with any emergencies and contingencies related to the research that may arise.

	Print Name	Signature	*Date*	
Principal investigator	**Sujan Shrestha**		*26./10/10*	

1. PROPOSED DURATION OF DATA COLLECTION COMPONENT OF PROJECT

FROM:	**16/11/2010**
TO:	**28/12/2010**

2. PROJECT DESCRIPTION:

The aim of this research is to explore the use of Wikireader and Nanonote devices as a potential mobile learning tool to provide affordable and sustainable offline mobile learning platform.

3. AIMS OF AND JUSTIFICATION FOR THE RESEARCH:

Before proposing, developing and piloting a mobile learning solution, the importance of considering an appropriate target mobile platform to deliver and support learning is one of the key aspects of a sustainable design. However, mobile learning researchers are focusing on integrating expensive new smart mobile devices (such as iPhone and iPod Touch) into schools and universities and delivering learning resources to meet students' academic needs. Our aim is to explore the possible role of low-cost open-source technology to identify the sustainable mobile learning solution.

4. RESEARCH APPROACH, METHODS, LOCATION(S) FOR DATA COLLECTION AND ANALYSIS:

Students are requested to participate in the initial stage of this research project. The approach of the research is through the use of a questionnaire and a contextual inquiry. At first, the questionnaire has been designed to obtain information about students, their desktop computer and mobile device using experience. Then, participants are given devices for 6 weeks period. Also, they are provided a diary and a pen to self-report their experience of using the mobile devices.

5. PLEASE EXPLAIN WHEN, HOW, WHERE, AND TO WHOM RESULTS WILL BE DISSEMINATED

The project will be piloted with content from the Mobile Application Development module which is part of the MSc Network and Mobile Computing course. We will have a small group of full-time students taking this module and be part of our developmental study.

All of the information obtained from this study will be kept confidential. All the data collected for this work will be presented in future publication anonymously. As this evaluation study is being supported by the Technology Enhanced Learning (TEL) project funded by the Institute for Teaching, Innovation and Learning (INSTIL) at University of West London (UWL), the results of this study will also submitted to INSTIL.

6. PLEASE GIVE DETALS OF PARTICIPANTS AND HOW THEY WILL BE RECRUITED

The project will be piloted with content from the Mobile Application Development module which is part of the MSc Network and Mobile Computing course. We will have a small group of full-time students taking this module and be part of our developmental study.

7. PAYMENT OR INCENTIVES: DO YOU PROPOSE TO PAY OR REWARD PARTICIPANTS?

No payments will be made. There are no costs to access resources from these specific mobile devices.

8. DOES THE RESEARCH INVOLVE:

	YES	NO
• use of a questionnaire or similar research instrument or measure? (attach copy)	x	
• use of written or computerised tests		x
• interviews (attach interview questions)		x
• diaries (attach diary record form)	x	
• participant observation?		x
• observation of participants (in a non-public place) without their knowledge		x
• audio-taping interviewees or events		x
• video-taping interviewees or events		x
• access to personal and/or confidential data? without the participant's specific consent		x
• administration of any questions, tasks, investigations, procedures or stimuli which may be experienced by participants as physically or mentally painful, stressful or unpleasant during or after the research process?		x
• performance of any acts which might diminish the self-esteem of participants or cause them to experience embarrassment, regret or depression		x
• investigation of participants involved in illegal activities		x
• procedures that involve deception of participants		x
• research overseas	x	

9. LIST ANY POTENTIAL RISK TO PARTICIPANTS AND RISK MANAGEMENT PROCEDURES

There are not any risks involved in this study.

10. LIST ANY RISKS TO RESEARCHERS

N/A

11. CONFIDENTIALITY / ANONYMITY

WILL THE RESEARCH INVOLVE:

	YES	NO
• complete anonymity of participants (i.e., researchers will not know the identity of participants as participants are part of a random sample and are required to return responses with no form of personal identification)?	x	
• anonymised samples or data (i.e. an irreversible process whereby identifiers are removed from data and replaced by a code, with no record retained of how the code relates to the identifiers. It is then impossible to identify the individual to whom the sample of information relates)?	x	
• de-identified samples or data (i.e., a reversible process in which the identifiers are removed and replaced by a code. Those handling the data subsequently do so using the code. If necessary, it is possible to link the code to the original identifiers and identify the individual to whom the sample or information relates)?	x	
• participants having the option of being identified in any publication arising from the research?		x
• participants being referred to by pseudonym in any publication arising from the research?	x	
• the use of personal data? *(If YES, you may need to register with the University)*		x

For further details about completion of this form, please contact Professor Andy Smith.

Publications

Please see 1.8 Conference papers and publications (pp.38-39).

Appendix M (Journal Paper 1): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2011). "Evaluation of a hands-on approach to learning mobile and embedded programming", International (IJMLO), Vol. 5, Nos. 3/4, pp.327–344.

Evaluation of a hands-on approach to learning mobile and embedded programming

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Abstract: Teaching and learning programming with a traditional classroom/lab based approach is challenging. Students often struggle to learn program due to lack of extensive hands-on practice. In this paper we report on an action research study of students' exploration and use of previously unexplored low-cost open-source mobile devices for learning programming. The study was conducted over a period of fourteen weeks in University of West London, UK with the postgraduate students studying Mobile Application Development module. We introduced the Wikireader, a handheld reading device and Nanonote, a lightweight pocket computer. We used mixed methods research methodology and data analysis was guided by the Framework for the Rational Analysis of Mobile Education (FRAME) model. The results of our evaluations indicate open-source devices have potential to enhance motivation to learn programming without being restricted to the limited practical sessions in the university lab and also facilitate offline reading.

Keywords: Copyleft Hardware, Open-source Hardware, FOSS, Learning Programming, Offline Mobile Learning, Embedded Programming, Mobile Application Development, Packedobjects, Nanonote, Wikireader, Mobile Usability, FRAME Model

Biographical notes: Sujan Shrestha is a PhD research student in the School of Computing and Technology at the University of West London. His research mainly focuses on exploring low-cost open-source mobile devices to facilitate teaching and learning. The aim of this ongoing research is to identify mobile learning challenges in the context of a developing country and giving the users a one-stop access to learning materials at anytime and anywhere without requiring to go online using smart devices.
John Moore is currently a senior lecturer in the School of Computing and Technology at the University of West London. He is a member of the Centre of Networks and Distributed systems. In addition, he is the programme leader for the MSc Network and Mobile Computing degree. John's research interests are focused around the application of dynamic programming languages within the domain of pervasive computing. Relevant work in this area includes, Packedobjects, a dynamic bit-packing tool. Other areas of interest include the use of copyleft hardware and software for educational purposes.
José Abdelnour Nocera is currently a Principal Lecturer - Postgraduate Field Leader and Head of Centre for Internationalization and Usability in the School of Computing and Technology at the University of West London. His main research interest lies on the co-configuration of people, culture and IT. Currently, a key point of his research is to continue to assess the value of technological frames and other sociotechnical perspectives to understand and inform the design, development

and evaluation of interactive systems.

1. Introduction

Technology is rapidly changing and the investment in exploration of advanced technology in education is also increasing. Due to the proliferation of technology, especially the mobile technology and its wide array of uses, the incorporation of technology in learning is widely considered and expected to deliver the learning outcomes. Even though the low-end phones are stable and widely available, they are not capable of supporting smart learning applications. Therefore, we frequently come across studies that explore the use of smart devices in educational settings, confidently making claim of increasing engagement and frequency of access and achieving better results. Even though applications based on smart devices may prove to be highly successful; the importance of considering an appropriate target mobile platform to deliver and support learning is one of the key aspects of a sustainable design (Shrestha et al. 2010b). The challenge for us was to select the appropriate flexible platform based on the clear understanding of the requirement of the curriculum and the issues related to existing pedagogy used, the limitations of available tools, the learning environment, and the need to support students meet their academic needs.

In this exploratory pilot study, our aim was to evaluate the usefulness of open-source mobile devices in supporting teaching and learning embedded programming by assessing its usability, probing how students used such devices and identifying problems while learning and provide support throughout the study period. Our focus was on the low cost open-source handheld mobile devices and this paper reports on an empirical study of the deployment of Nanonote, a lightweight pocket computer and a handheld offline reading device Wikireader with the group of twelve students studying MSc Mobile and Networking.

We begin by highlighting the background of the Mobile Application Development module, the related curriculum, the pedagogy, languages and tools used. Then, the context of programming education and benefits of introducing mobile devices to support learning is discussed. Next, we highlight the open-source platforms, possible benefits of such approach in teaching and learning programming and introduce the Wikireader and Nanonote devices. Then, we discuss the research methodology and elaborate on the research approach we used in this pilot study. Finally, based on the FRAME model for mobile learning, we analyse our findings and conclude by reflecting on our results and the overall study.

2. Background: Mobile Application Development (MAD)

The pilot study was carried out in University of West London with a small group of twelve full-time students studying Mobile Application Development (MAD), a 20-credit module which is a part of the MSc Network and Mobile Computing course. This module has been developed to provide hands-on experience developing software for mobile devices using an open source approach to software development and students are expected to gain experience using relevant industry standard tools to support their work. It introduces the student to the difficulties associated with developing software on embedded devices and provides a background to embedded development. It enables the student to gain experience in different programming languages typically used for mobile and embedded development and provides the student with the foundation required to enable skills transfer to an industry equivalent situation.

2.1 Curriculum, Pedagogy, Languages & Tools

The MAD module is delivered over the period of fourteen weeks and there are two parts in this module. At the beginning of the first seven weeks, students are introduced to various concepts of mobile and embedded computing; the types of hardware found in mobile and embedded devices; understand constraints of existing open-source hardware and the impact of open-source software in embedded computing. Then, students start familiarizing with tools to work on the desktop computer. The focus is on the use of C Programming language to understand why C is the dominate language for embedded system; the challenges of working with C and its alternatives. Students learn the concept of cross compilation and experience using the related tools. They are also introduced to Glib - a utility library as a high-level approach to working with C.

In the next seven weeks; building on the experience from what they learned, students are introduced to Scheme programming; process of embedding Scheme into C and learn to deploy application on the embedded devices. They appreciate how to work with binary data using Packedobjects (Moore 2010) and develop familiarity with high-level approaches to application development. The focus is on the scripting (communication & serialization) and enhance practical skills such as network programming. Packedobjects is a data encoding tool that provides high-level bit-packing on low-level devices and provides specific flexibility when working on embedded systems. This dynamic approach provides advantages over traditional programming language such as C and C++ by reducing the amount of cross compilation and deploys cycles. The students also understand difference between mobile and desktop graphical development and introduced to graphical toolkits such as GTK+.

This module provides three hours of class contact per week. One hour for a formal lecture and two hours of practical lab classes. The primary learning approach is based around lectures on specific topics supported by lecture notes; additional reading & case study material guided via Module Study Guide; followed by tutorial / practical sessions on applying the lecture content to specific practical activities. The reading and discussions are also facilitated via the university e-learning platform (Blackboard) and students are encouraged to participate and collaborate in class and electronically.

Students enhance skills writing open source software and understanding of how to write software in a portable way. As part of the development process students are required to use standard open source development tools such as the 'autoconf' build system and the version control system 'git'. Packedobjects is available as a module for GNU Guile which in turn is available as a C library. By linking with this library provides an access to a Scheme interpreter which amongst other things allows manipulation of structured data in the form of symbolic expressions. Using GNU Guile, students are required to complete two assignments of one element each at the end of the seventh and the fourteenth week which require developing a command-line application that is capable of communicating structured binary data across a TCP/IP network and suitable for deployment on a Linux based embedded device.

3. Literature Review: Learning Programming Using Mobile Devices

Learning programming is not easy and there is no shortcut in learning to program (Hassinen and Mäyrä, 2006; Sheard *et al.*, 2009). “Programming language concepts are highly logical and therefore difficult to understand by conventional study materials” (Patil and Sawant, 2010). Generally, the traditional learning approach of concepts first is common which is based around lectures on specific topics, followed by tutorial / practical sessions on applying the lecture content to specific case studies and there are various programming languages and tools to support teaching and learning.

In a comprehensive survey of research in the literature on the teaching of introductory programming, Pears et al. (2007) grouped programming tools as visualization tools for algorithm animation and code; automated assessment tools for checking assignments; sophisticated Integrated Development Environment (IDE) for virtually all widely used programming languages; programming support tools which offer a limited subset of the capabilities of a professional IDE; Microworlds that provide environments based on physical metaphor and expert intelligent tutoring systems for supporting introductory programming. Despite the large volume of literature in this area, authors could not find a systematic evidence to support any particular approach and seeks to provide support for a wide variety of approaches for teaching programming.

Learning programming is delivered using different pedagogical methods such as traditional face-to-face in classroom or lab and online or using mix of both. Bruhn & Burton (2003) studied the use of computers in the classroom to help students better understand programming concepts during classroom presentations. Even though this approach helped the average-to-poor students' achievers the most, it needed more time to present the material to the students and it also took time for students to practice programming concepts on the computer in class. Miles (2011) compared the satisfaction and success of learning programming using traditional face-to-face (f2f) and the other totally online. The results showed no significant difference in the satisfaction level of the two groups, but online students scored significantly lower than students in the traditional classes. Authors highlighted that the other factors such as inexperience in taking classes online, motivational issues and sample size could have affected the findings as well.

Research studies related to programming education clearly identify the lack of extensive hands-on practice and sufficient time to become familiar with programming concept as the main reason for students to struggle to learn program. A traditional setup of a programming course that depends largely on lectures and a handful of assignments fail to provide the kind of learning experience that many students require (deBry, 2011). Hence, a clearer approach to teaching programming is needed (Milne & Rowe 2002). Research shows that only through adequate practice and training can expertise be obtained in the field of programming (Bruhn & Burton 2003; Ala-Mutka 2004). Thus, the need is to focus on enhancing experimental learning. The UK government's backing for calls for classroom coding and hands-on approach to teach by exploring the innovative and affordable computing platforms for stimulating and motivating children also highlights this need (BBC News 2011b; BBC News 2011a; DCMS 2011).

It is even far more important to understand that the mobile application development requires a considerably different approach compared to applications for the desktop computers and need the understanding of the complexity of their operating environment, which is much less predictable than contemporary fixed wire networks, and the restrictions placed by the devices themselves in terms of memory, power, speed, screen size, etc. (Edwards and Coulton, 2007). Therefore, it is important to encourage students to gain practical skills to develop applications with the understanding of the existing limitations of the mobile platforms that a developer faces daily.

Some of the proposed approaches to teaching computer programming are using robotics or through the use of game design and using mobile devices (Mahmoud & Popowicz 2010). Introduction of mobile devices in programming education provides the practical development experience students need and also become aware of the development challenges they present (Mahmoud & Dyer 2008; Mahmoud & Popowicz 2010). Research has shown a learner-centered approach to teaching programming is effective and successful (Moura, 2011) and the use of a hands-on oriented approach in introductory programming courses has shown increase in a positive experience and improve learning (Kulkarni 2010; Richards & Smith 2010; Q. H Mahmoud & Popowicz 2010).

However, the analysis of research papers about programming education published in computing education conferences identified only few studies that considered online distributed or mobile learning in programming education (Sheard *et al.*, 2009). We approached teaching programming by using mobile devices to provide relevant programming knowledge and these devices can also be used for hands-on practices which can make lessons more engaging compared to lessons where a traditional approach is used. At the time of this review, we were not aware of research studies that explored open-source platforms particularly the Nanonotes and WikiReaders in such a programming education context.

4. Open-source Platforms

"The advantages of Open Source Software (OSS) development model are already quite well understood and documented in empirical research" (Malinen *et al.*, 2010). OSS gives users the freedom to run, modify and redistribute copies of either the original or modified program. But the emergence of "app stores" model provide a platform where small applications are exchanged for small amounts of money without any requirement to share code and there are growing evidences of apps developers using open source components to speed development of applications. A recent study found around 70% of (Android and iPhone) mobile apps containing open source code fail to comply with their respective licenses obligations such as making source code available and providing a copy of the license (Samson, 2011).

Our aim is to encourage sharing of knowledge and therefore believe in using mechanisms such as copyright law to guarantee every user has freedom and anyone who redistributes the software and hardware design, with or without changes, must pass along the freedom to further copy and change it. The approach is known as "copyleft". But the popular Apple apps store restricts usage and imposes further limitation on usage rights that were envisioned by the original licensor of the open source code (Rodrigues, 2011). Similarly, Windows Microsoft licenses bans products containing open source code (Halfacree, 2011). Therefore, an apps store approach to mobile application development is restrictive as it discourages the use of open standards. However, the mobile industry is dominated by proprietary technologies and this situation is mirrored throughout academia.

Even though OSS development has received increasing scholarly attention, the research on open-source hardware (OSH) is still in its early stages (Malinen *et al.*, 2010). The open-source hardware supports creativity by offering flexibility in both design and function without being constrained to the system created by the maker (Mellis and Buechley, 2011), whereas a locked down device restricts creative and innovative development (Moore et al. 2009). There are several established OSH projects (http://p2pfoundation.net/Product_Hacking) providing opportunities for the community to directly influence the hardware roadmap of a device and thus generate possibilities for creating new and sustainable solutions within specific markets. For example, the Robotic Open Platform (http://www.roboticopenplatform.org/) is an open source system for robot hardware designed to serve as a library that robot developers can use to add their designs or improve existing robots, allowing the community to build the robot at a relatively low cost.

However, open-source hardware projects have been less influential and successful than their open-source software counterparts as it may need a complex or expensive software tool to design and may encounter difficulties in separating design and construction (Mellis and Buechley, 2011). It also faces several challenging questions such as whether the open-source software model is transferable into physical production or not, how would business benefit from open sourcing hardware and who is really going to make their own device? (Weiss 2008; Malinen et al. 2010). However, "as it has happened with open source software, though, it may take some years and test cases for legal clarity to emerge in open source hardware" (Weiss, 2008).

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and the template-based coding systems which is commonly used to study the hardware to understand how it works, make changes to it, and share those changes. BeagleBone and Raspberry Pi provide further learning possibilities with full-featured developer-friendly Linux OS. These devices do not have a case, and do not implement a local keyboard allowing complete access to hardware needed for programming applications such as controlling a robot.

Another promising low-cost open copyleft hardware device is the Nanonote (Figure 1a) by Qi Hardware. It is a general purpose computer, an ultra-small form factor computing device. It runs embedded Linux distribution (OpenWrt, which is usually found in Wifi routers) and uses a kernel, bootloader and root file system that can be flashed over the USB port. The device is however still in its infancy and does not have a built-in wireless capability. The device is not designed to be mass marketed consumer electronic product and at the moment, it is targeted at developers, so that it can be turned into something useful as necessary such as a media player or a gaming device or a learning device. Compared to devices such as Arduino, BeagleBone and Raspberry Pi, Nanonote comes with a case, local keyboard and the 3.0" color TFT display. Therefore, it can be used to develop any kind of application and also has the added benefit for users to use it while on the move.

As the restricted license of a proprietary devices do not allow using hardware designs freely, the copyleft approach ensures the design is always open for a complete customization, enhancement or extension, allowing the community to influence its future hardware revisions and there is no end of life for devices as in a proprietary system. If coplyleft approach used, even if the device fails, it can at least ensure that the design can continue to live and be improved in future. Camargo's Swiss Army Knife Card (http://en.qi-hardware.com/wiki/SIE), which adds a field-programmable gate array (FPGA) and is used for analog signal processing is the first externally-developed project based on the Nanonote.

Figure 1a. Ben Nanonote - an ultra-small form factor copyleft computing device which has 336 MHz XBurst CPU, 3.0" display and 2GB NAND flash memory. Figure 1b. Wikireader – offline handheld reading device.

The low-cost WikiReader (Figure 1b), by Openmoko is a non-wired offline mobile device. Its software platform is open source and freely available. Initially, it provides the content of Wikipedia (an electronic encyclopedia), which can now be updated to display in so far eighteen different languages. It allows the software developer to customize or adapt the software and contents as necessary and it also offers an interesting alternative to the phone for supporting offline mobile learning.

"Open source software offers great opportunities to bring real-life experience directly into the classroom and in particular, it can be used to emphasize the importance of high quality software design, the role of design patterns, the need of good documentation, and the relevance of social skills in a real-world environment" (Pedroni et al. 2007). "The free and open-source software (FOSS) culture, principles, and practices are very much suitable for a student-centered educational environment that is inquiry-based, highly collaborative, motivational and relevant, and inclusive of diverse abilities, cultural backgrounds, and life experiences" (Sabin 2011).

Open-source hardware platforms can also be used in the context of teaching and learning programming. Simple and affordable devices can greatly improve the interest in the subject and allowing students to try their skills on a real hardware can make it easier to concentrate on the programming problems. It makes the lessons much more attractive for students and also their results are better compared to lessons where only simulators and/or computer models are used (Dolinay *et al.*, 2011). But the transforming of teaching to create effective learning environments has many challenges related to types and scope of projects students get involved with; infrastructure resources and expertise needed to carry out these projects; learning outcomes and assessment measures; and limitations and barriers experienced with various teaching approaches (Jacobs *et al.*, 2011).

However, as the access to open-source technology is improving, a well-designed open-source oriented course utilizing open-source software and hardware platforms can help to create a learning space (deBry, 2011), a space where students feel supported & respected, a space that is open to conversation by its nature, a space for developing expertise by challenging to write good code and a space where students are motivated to take ownership for their software and hardware and encourage to experiment with the complete freedom and practice what they learn.

5. Research Methodology

In this study, we took an action research approach. The basic premises of an action research paradigm are that the research is "participative, grounded in experience, and action-oriented" (Reason and Burgess, 2001 p.xxiv in (Lunsford, 2010). The students' participation helped not only to evaluate the devices but also to understand the problems they faced while learning programming and to provide the necessary support during the study. The study was supported by Institute for Teaching, Innovation and Learning (INSTIL) which provides support and leadership on all aspects of teaching and learning in University of West London. The goal was also to disseminate the findings within the University for the wider use of other staffs and students that could lead to possible changes in practice.

For the evaluation purpose, selection of the research methods for this study was based on earlier studies of adoption of mobile technology for learning by (Corlett *et al.*, 2005; Waycott, 2004). To capture the unique elements of the participants' experience, where possible, flexibility was built into the study by not committing to a particular route and regularly reviewing possible approaches to data collection (Dearnley and Walker, 2009). From the fields of Mobile Human Computer Interaction and Mobile Design research (M-HCI/D), this research employed mixed research methodology, which is the most common approach used in programming education research (Sheard *et al.*, 2009), to gather and analyze quantitative and qualitative data on mobile learning and usability. Due to exploratory nature of this research, data analysis was iterative and reflective process throughout the study. The data was examined in relation to the Framework for the Rational Analysis of Mobile Education (FRAME) model, which is discussed next.

5.1 Framework for the Rational Analysis of Mobile Education (FRAME) model

Research shows the lack of specific models for teaching and learning of programming and research studies that investigated learning within a theoretical framework to explore the process of learning (Sheard *et al.*, 2009), which is important to deepen our understanding of students' behavioral or affective responses to their learning or teaching experience. Our aim was to study the feasibility of open-source platforms for teaching and learning programming, therefore we adopted the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2009).

"The FRAME model describes mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction" (Kenny et al. 2009; Koole & Ally 2006). There are set of three intersecting circles representing the device (D) which describes characteristics unique to electronic, networked mobile technologies; learner (L) describes characteristics of individual learners; and social (S) aspects describes the mechanisms of interaction among individuals (Koole and Ally, 2006).

The overlapping intersection of the FRAME model representing the device usability (DL) and social technology (DS) describe the affordances of mobile technology; the interaction learning (LS) contains instructional and learning theories and the primary intersection (DLS) in the center is a convergence of all three aspects, defines an ideal mobile learning situation (Koole, 2009). As we were introducing a new technology, the main focus of our pilot study was in the device (D) and the learner (L) aspects and its intersection device usability (DL).

The low-spec Wikireader and Nanonote devices are not equipped with various technical capabilities, such as short messaging service (SMS), telephony, and access to the Internet through wireless networks. Therefore, these devices do not enable active communication between the students and tutor. Nevertheless, we wanted to maintain the existing culture of face-to-face and online cooperation and communication between students' and tutor in the classroom, lab and through the Blackboard virtual learning environment and facilitate learning by introducing these devices (Koole, 2009). Students were also encouraged to engage in problem solving activities and where possible exchange knowledge and collaborate. It is however important to fully explore the social technology and interaction aspects of using mobile devices which are important to fully utilize the affordances of the devices especially in the context of mobile distance education and blended learning (Kenny et al. 2009).

5.2 Study Approach

The first part of the module was taught using combination of lecture and practical class where students had hands-on experience of programming in the lab. But on the second part of the module, they were also given Nanonote and Wikireader devices to take away and use until the end of the term. The students were not trained specifically to use these devices, as they were expected to explore and use the devices to support learning programming. The organization of this study and the data collection was completed in four months starting September 2010.

At the beginning, we obtained the written informed consents from the students who agreed to participate in this study and administrated the pre-questionnaires and analyzed the demographics. Then students randomly selected the devices, so that the six students had Wikireaders and other six had Nanonotes. As prerequisite, the students were expected to be familiar with some programming and Linux desktop environment and where available, they were also encouraged to setup Linux system in their personal machines.

As the students were studying other two modules as part of the MSc course and busy with assignments, we realized the data collection techniques have to be simple and this study should not be felt as a burden to them instead of our goal of providing support for learning. Therefore, even though we initially planned to use the diary study method, students were requested to keep the log of their activities instead. Research shows that diary study method can suffer from the drawback of potentially missing data, because participants may forget to record entries or are selective in reporting (Bolger and Davis, 2003), and also possible that they may find it difficult to write unprompted (Hall, 2008). In the activity log, students simply recorded *when? where? why?* They used the devices and documented if they found them useful and also record the problems or difficulties they faced. The simple log provided an effective way to monitor progress and also identify learning issues early and provide appropriate support.

Finally, post-test questionnaire at the end of the study was used to find out what features of the device the students had used and whether they had found it to be a useful tool for supporting learning and what the benefits and limitations of the technologies were. The activity logs were also used in a supplementary manner which helped to further understand the students' view that they expressed in the post-test questionnaires.

6. Device Aspect (D)

According to Kenny et al (Kenny et al. 2009) mobile learning is constrained by the mobile device hardware and software configurations and dependent upon adjustments in teaching and learning strategies. The selection of the open-source mobile platforms (Nanonote and Wikireader) for this study was based on the requirement of the subject. The devices were comparatively cheaper, freely customizable and portable that students could use anytime anywhere without incurring extra cost. The use of such cost-effective open-source platforms supported creativity and provided expected freedom for teaching and learning mobile and embedded programming based on open-source practices.

The university has a Windows based network and there is no dedicated lab for Mobile and Networking students. However, in one of our lab, we setup each computer with a dual boot Ubuntu and Windows operating systems. In the existing system, university does not allow students to install necessary open-source software. Therefore, by introducing these mobile devices helped to relax such constrains and provide total freedom for students to practice programming in the university and also outside the institutional contexts. University also restricts access to Wireless network using mobile devices and hence one of the reasons to adopt the offline mobile learning approach.

The Nanonote devices were customized to support the necessary software to provide hands on experience of packing data and communicating it across different kinds of hardware. Setting up devices was a non-trivial task, but worked well after careful preparation. Due to the specialized nature of the module, students were also free to customize their devices, such as changing the default distribution and adding multimedia content. The device related and available software are well documented and freely available online.

The Nanonotes were configured with lightweight JlimeMuffinman Linux distribution which has been built using OpenEmbedded with Jlime look and feel. It included already configured several useful stripped-down versions of applications to supplement it and also a complete software repository. The current image provided a X Environment, Matchbox window and desktop manager, and several useful applications such as video player, music player, image viewer, text editor, terminal, PDF viewer, dictionary and games. The devices were then loaded with necessary PDF manuals.

The Wikireader devices were also customized to provide access to necessary resources. Initially, the plan was to setup a course wiki based on the university’s virtual learning environment (VLE), so that the lecturer can create and edit articles, but anyone can read those articles and leave comments. But, to customize the Wikireaders, we needed to upload the content from the course wiki to the device, which required importing an XML dump to be compiled and copied to micro-SD cards. Due to lack of flexibility of the existing VLE, we had to setup a new Wiki site using an open-source Mediawiki of which we had a full control. The site was setup in such a way that only the lecturer could edit the pages. Then, Wikireaders were customized to provide an offline access to Packedobjects manual and also imported other useful freely available wiki resources.

7. Learner Aspect (L)

Our Masters programmes attract overseas students, mainly from India. These students can have difficulties adapting to a UK university learning environment. Some of them also have limited access to ICT resources outside the university. Previously, we have also experienced students’ inability to make a significant improvement in MAD module due to lack of programming skills and unfortunately many dropouts or change their course pathway where programming is not compulsory. While those who decide to do this module, many struggle as they often fail to recognize their own deficiencies.

In this pilot study, all the students were male and were below 25, except for one student with age range 26 – 35. All the twelve students had regular access to desktop computer with Internet at home or university lab and library and good experience of using them for personal, work and study purposes. They also owned variety of mid-range to high-end mobile phones. 83% of students had post-paid (contract) phone but only 33% students had data usage plan. Most of the students were concerned about the cost of using mobile internet. Some of them did not need to use mobile phone for browsing as desktop use was sufficient for them and when available, some students preferred desktop computer to mobile device for accessing the internet.

Previously, none of the students had seen or used these relatively new Nanonote and Wikireader devices. However, they were enthusiastic and showed interest in participating in this pilot study as they thought it would be useful to have an access to resources offline to support their study and also use for hands-on experience.

8. Device Usability (DL)

While Wikireader is a dedicated offline text reading device, Nanonote is a general purpose Linux computer. This study is therefore not a comparison between these two different devices but instead their evaluation for the purpose of teaching and learning mobile and embedded programming.

8.1 Wikireader

All the students said they used the Wikireader a few days a week to read and used it at home and while travelling as well. Most of the students found it easy to use and very useful for reading, while only 1 student found it somewhat useful. The most important advantage that students highlighted was the readily available content without using Internet in the portable, handheld and easy to use Wikireader device that supported uninterrupted reading at home or at work and also while travelling. As one of the student described the benefits: "*easy learning process, can be used anytime, anywhere, easy to carry in the pocket, no need of internet, low cost and very fast access to useful information*".

However some of the concerns were the difficulty to search long phrases, sometimes not getting results as expected, having to go back to 'home' while navigating through the text, poor screen resolution, not knowing how to adjust backlight and not being able to read on nights. Most of the students found onscreen keyboard neither easy nor difficult to use, while 2 students found somewhat difficult to type as they found touch screen of a low-resolution display unsmooth.

The low-powered Wikireader device was easier to use and read texts. All the students found the 'Search' and the 'History' functions very useful and easy to use. But only 2 students found the 'Random' function useful, while 1 student found somewhat useful and 2 students never used this feature. Only 2 students used the device for reading other than the Packedobjects software manual. They found dictionary and quotes particularly useful.

Students did not need to update the device as it was provided with the necessary resources. There is no automatic synchronization or straight forward updating mechanism for customized software and the content. For newer content, the device software needs to be recompiled with XML dump and copied to the MicroSD card. A further research is needed to develop a tool to facilitate this process so that a student can also customize the device easily. Therefore, we encourage students to explore the open-source platform, understand the limitations and opportunities and appreciate its benefits to full potential.

8.2 Nanonote

In our study, 4 of the students used the device a few days week, while the other 2 students used only once a week. They used the device mostly at home and used while travelling as well. Half of the students said reading on Nanonote was rather easy and the other students found somewhat difficult. They found reading PDF on the Nanonote was difficult due to small (3" size) screen and the difficulty to use the compact 59-key keyboard which had a considerable impact on the ease with which students could navigate through text. Even though students found thumb typing on the Keyboard convenient, they felt it was slow due to its layout and the small keyboard buttons and therefore said it needs more practice. In general, using the device required remembering functions of certain keys or combination keys.

Even though some of the students found the Nanonote useful for reading PDF documents (especially the slides), they initially found difficult to use the device and the software. Reading normal PDF documents required extensive scrolling both horizontally and vertically and also needed to remember different keys configured to start and close the application, zoom in and out while reading the document and to go to different pages.

However, beyond reading documents, a student also found Nanonote very useful for listening mp3 audio and watching videos while travelling. The video was compressed using freely available software and copied to the device. While all the students appreciated the use of Nanonote to understand and learn the programming for embedded devices, a couple of students flashed the device with the minimal OpenWrt image containing GNU Guile and used for testing the command-line software they developed as part of the second assignment. As they had an unlimited access and control of this device, students were able to install and remove software, customize as necessary which they could not do in the lab computer. However, it is likely that prior instruction in their use will be needed as most of the students felt customizing Nanonote will be somewhat tedious for the novice Linux users.

9. Analysis of Activity Logs

Regardless of lack of Wireless connectivity, all the students said that they used Wikireader both at home and while travelling, but Nanonotes were used mostly at home. From the activity logs, we found 60% of the usage of the devices was at Home and 40% was while travelling (Figure 2). They used both devices from few minutes to half an hour and up to maximum one hour. While using Wikireaders, all the students said that they sometime made notes on paper but only two users made notes on the paper while using the Nanonote.

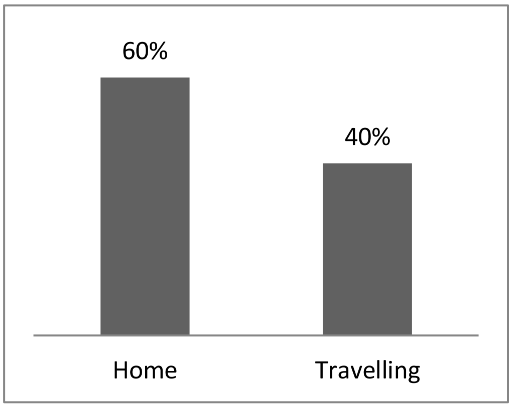

Figure 2. The overall usage of the offline devices

The analysis of log shows, results of the 70% of the activities on Nanonote devices were useful, 10% of the results were somewhat useful and 20% of the results were not useful. On Wikireader device, students found the results of the 77% of the activities useful, 9% of the results somewhat useful and only 14% of the results were not useful (Figure 3).

From the log we were also able to quantify the number of problems students encountered while using these devices (Figure 4) and the result supported the views students expressed in the post-test questionnaire. It shows that students encountered 60% of the usability problems and 40% were the technical problems while using the Nanonote devices. They faced technical problems such as difficulty in setting up DNS forwarding, difficulty in installing the tools needed on the desktop, which were solved with tutor’s support in the lab. But it shows there were usability related issues especially the difficulties of using the software, the small keyboard and navigational issues while reading the content.

Wikireader users noted 28% of the technical problems related to typing especially long phrases on the touch-screen and 72% of usability issues were related to adjusting backlight, sleep mode and navigating using back button. Some of the activities were also related to searching for information unrelated to the course and students found unsatisfactory or limited results.

Portability: Even though these devices are small enough to fit into pocket and easy to keep it safe and secure physically, one of the students lost the Nanonote in the last week of the pilot study. But it did not have any implication to the student or our study.

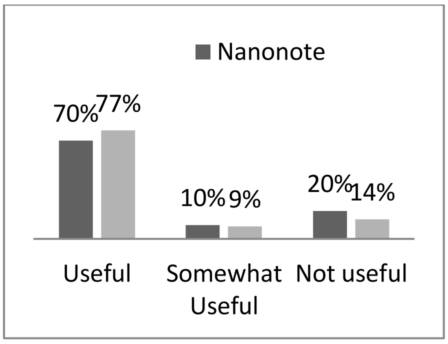

Figure 3. The analysis of the results from the total number of activities students completed

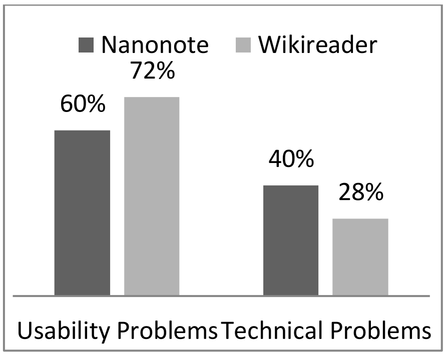

Figure 4. The analysis of the total number of problems students encountered while using the devices

10. Limitations

The aim of this study was not to identify and measure the impact on learning embedded programming and also not meant for generalizing our findings to a larger population due to small number of students participation in a short period of the study. Therefore, the findings of this study should be used with caution to inform other programming education related studies. As this study mainly focused on the device usage, the results provide indications on students' perceptions towards the effectiveness of open-source platforms for student support and the findings could also be useful to support the adoption of offline mobile learning model to provide an access to resources and support learning.

11. Conclusions

Programming for embedded devices requires understanding of restrictions in terms of hardware and also the software environment. With an apps store approach students fail to understand the incompatibility issues between platforms that restrict building an application to tailor for multiple device platforms. We studied a hands-on approach of teaching mobile and embedded programming using an open source approach to understand the difficulties associated with developing software on embedded devices. It helped students acknowledge the benefits of learning programming using open-source platforms.

In this paper, we reported an exploratory evaluation study of research-oriented low-cost open-source mobile devices to teach embedded programming. It has helped us to identify the benefits and limitations of the Wikireader and Nanonote devices by exploring how students perceived and used these devices, and how well they believed these devices supported their learning activities. This has demonstrated the feasibility of a hands-on approach that can be used to improve the further use of such devices in teaching embedded programming. We believe that the chosen platform allowed us to move our pilot to the mainstream of educational provision and we continue to use the hands-on approach for teaching and learning programming.

In this study, the Nanonotes and Wikireaders were perceived by the students to be an effective tool in support and learn embedded programming. An access to these mobile devices provided opportunities for students to use the devices throughout the term for learning. Students found Nanonote device more useful for practicing hands-on programming for embedded device than general reading purposes. To fully appreciate the potential of this general purpose palm size computer requires developing custom software and content. While Wikireader device can also be customized, students found it more suitable for uninterrupted anytime anywhere offline reading. Students were not concerned about the lack of wireless Internet access, as the devices were provided with required resources for the specific subject they were studying.

We believe offline mobile education also has a broad application scope, as it will minimize the complexities of providing mobile learning by not having to deal with networking issues, malleability of design and content, simplicity and no steep learning curve (Shrestha et al. 2010a). As one of the important challenges of broad areas for mobile computing is building applications that deal with the arbitrary disconnected nature of mobility, i.e. offline (Yang, 2000), building networks and applications that can deal with intermittent services will be important (Dearden *et al.*, 2010). Therefore, this study recommends further explorations of the potential of open-source platforms to develop an effective and sustainable offline mobile learning solution to provide ready access to resources and support teaching and learning. For example, Amazon’s Kindle hardware, web-based and native applications for mobile and desktop computer make easy to read online and offline, anytime and anywhere. HTML5 based version of software uses the Web to get around restrictive policy of a dominant, locked-in apps store and allows downloading and storing books for offline reading.

This study also highlighted that to take a full advantage of devices as such and to progress quickly, students must be supported in the early stages and their usefulness must be visible to them at the beginning. As the students are usually under pressure to complete assignments and prepare exams for different modules, they are unlikely to invest valuable time learning the devices so that they could possibly use for supporting the study. It is crucial to identify and provide the useful resources that students really need and align the use of the devices with the requirements of the module to enhance the learning experience by exploiting the potential added value these devices could bring.

Access to open-source platforms is critical to supporting teaching and learning mobile and embedded programming. Even though open-source platforms provide the greater flexibility and freedom that can be leveraged to shape the design of future cost-effective and sustainable mobile learning solutions that students really need, it is also important to provide a satisfactory user experience at the same level or else effectiveness of using such devices cannot be realized and the solution is more likely to fail.

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Appendix N (Journal Paper 2): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2011). "Mobile learning and low-cost hardware for ICT4D: what's right and what's copyleft?", Special Issue - IEEE Multidisciplinary Engineering Education Magazine (MEEM), 6(1), pp.14-21.

Mobile Learning and Low-cost hardware for ICT4D: what's right and what's *copyleft*?

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Abstract—**In developing countries, mobile devices can play an important role in delivering learning. However, poor information infrastructure and higher costs of mobile devices and connectivity restrict possibilities of providing successful mobile learning services. In the field of Information Communication for Development (ICT4D), this research aims to highlight the possible role of previously unexplored open-source platforms for delivering affordable and sustainable mobile learning. Based on thorough analysis of current tools, technologies and research, this paper discusses considerable challenges faced by technologies designed for ICT4D. While this paper highlights the possible benefits of copyleft designs for custom hardware, it also highlights the need for a broader study to investigate its potential role in developing countries as supporting mobile learners in their own socio-cultural contexts is a significant challenge.**

Index Terms—**copyleft hardware, ICT4D, ICT4ED, low-cost computer, offline mobile learning, Nepal, open-source platform**

INTRODUCTION

MOBILE phone users growth rates are fastest in the poorest regions (Heeks, 2008). Potential of mobile technologies is also increasingly being explored as a new range of hardware platforms on which innovative systems may be built to help bring services and new opportunities to the poor (Dearden *et al.*, 2010).

However, the affordability of computing remains a primary barrier in developing regions (Ho. *et al.*, 2009). As Mekuria (Mekuria, 2009) pointed out, "the innovative mobile web & broadband services, require next generation mobile broadband technologies and advanced terminals for a successful launch and operation, affordability and reliability of such services, together with usability of mobile services, become very crucial parameters to understand and solve, for the uptake of web-based mobile services in developing regions".

Even though the number of web users is growing, a significant number of people still do not have regular, effective access and ability to use digital technologies (Boyera, 2008). By mid-2009 mobile penetration in Nepal had quickly moved to 20%, with mobile subscriber numbers having increased tenfold in just three years. But the Internet segment of the market remains sluggish; Internet user penetration was still down below 2% in early 2009 (Research and Markets, 2010).

Among other similar issues of infrastructure across the developing regions, Nepal's topography makes it extremely difficult to develop the much needed telecommunications infrastructure and the country is struggling under an adverse economic situation caused largely by current political instability. According to the United Nations Development Program, poverty in Nepal has increased over the past three decades, especially in rural areas (UNDP, 2010). About 86% of population lives in rural areas and dependent on subsistence agriculture for their livelihood and availability of electricity is limited to about 18% of the total population, while the rural population has just about 5% (Vaidya and Shrestha, 2010). Previously, in a bid to cope with the power crisis that has plagued the country, The Nepal Electricity Authority (NEA) announced

12-hr daily load-shedding(nepalnews.com, 2010a). Today, people are still suffering through crippling electricity cuts. The NEA is currently preparing to hike the electricity tariff by 30 percent and also said that the country will continue to reel under power cuts for six to seven more years and in this dry season, the duration of load-shedding will be up to 14 hours a day(nepalnews.com, 2010b).

Therefore, regardless of rapid development of mobile tools and technologies, supporting learning in Nepal's context faces numerous challenges. According to Dörflinger (Dörflinger, 2009), a large scale, low cost deployment of SMS based service is impossible and also to make usable Mobile Web requires the concepts of UI design, application (mobile browser, web content) design and mobile interaction design to be rethought especially for this new user group in a completely new environment Also, without an understanding of how the mobile internet is used in resource-constrained environments in the developing world, it will remain difficult to identify its ―impacts or how to best promote its utility in the context of Nepal(Donner and Gitau, 2009).

Weiss (Chhanabhai and Holt, 2009) states that "in underdeveloped areas of the world, the costs to implement sophisticated telephony systems can be prohibitive, resulting in populations cut off from modern opportunities". Even though GPRS/3G networks and handsets are coming down in cost, common use of expensive smart phones is not yet possible in Nepal. As the cost of the device is one important factor, only inexpensive platforms can facilitate rapid application development (Ledlie *et al.*, 2009). Thus it is important to consider cost-effective alternative platforms to high end mobile devices.

Kristina et al.(Pitula *et al.*, 2010) identified three main thrusts of ICT4D initiatives, which are: (1) developing infrastructure to provide power, connectivity, and devices appropriate for the prevailing conditions in a sustainable manner; (2) building ICT capacity corresponding to the skills and competencies necessary to maintain and use the technology; and (3) providing digital content and services. Considering the context of Nepal, this research goal is to support the need for access to knowledge and address the challenges and issues of delivering learning in government schools of Nepal. It mainly focuses on understanding how can an open platform be used for delivering affordable and sustainable offline mobile learning(Shrestha *et al.*, 2010a)? It will evaluate a low-cost open source mobile learning technology and identify the implication of introducing a new technology in a resources-constrained environment.

This paper discusses the challenges of the mobile learning field and ongoing ICT4D research. Then it highlights some of the key low-cost computer projects and how copyleft hardware approach may help to develop sustainable solutions. It will further attempts to highlight the importance of selecting an appropriate mobile device as part of the sustainable design. Next, it briefly describes the research methodology to be applied and research approach for the proposed study in Nepal. The final part highlights the expected contribution.

Mobile learning

Rapid mobile communication technology developments have given opportunities for economic and social development in developing countries. According to Joshi and Avasthi (Joshi and Avasthi, 2007), mobile phones are increasingly becoming pervasive and for a large group of people mobile phones are the first and only interactive digital media they directly operate and experience. Mobile access to digital content is improving and it is already playing a central role in bridging the digital divide. There are examples of how simple handsets and networks are beginning to produce indispensable services such as M-PESA (Hughes and Lonie, 2007) in Kenya and Healthline (Rahman, 2007) in Bangladesh.

Mobile learning (M-learning) is a relatively new research area and it uses mobile technology to facilitate learning. Traxler (Traxler and Leach, 2006) describes 'mobile learning' as the term increasingly being applied to the use of small, portable, handheld and lightweight electronic devices used for educational activities in classrooms, in fieldwork, at home, at work and when travelling.

Mobile education application models can be classified into three categories: 'permanently online', 'frequently online' and 'offline' and they bear their own advantages and disadvantages (Qian and Nan, 2008). According to Qian et al. (Qian and Nan, 2008) applications of permanently online mobile education rely on the wireless network, and to most learners permanently online is hard to achieve and not necessary.

They also suggested offline mobile learning with no interaction with servers is also not acceptable. But, one of the important challenges of broad areas for mobile computing is building applications that deal with the arbitrary disconnected nature of mobility, i.e. offline (Yang, 2000). As building networks and applications that can deal with intermittent services will be important (Dearden *et al.*, 2010), in the context of developing country, offline mobile education has broad application scope, as it will minimize the complexities of providing mobile learning by not having to deal with networking issues, malleability of design and content, simplicity and no steep learning curve (Shrestha *et al.*, 2010a).

However, Vavoula and Sharples (Vavoula and Sharples, 2009) have highlighted the lack of standardization in terms of research frameworks, methods and tools in the mobile learning field. Moreover, the learning material is often developed with proprietary specifications, preventing content from being shared and reused (Nakabayashi *et al.*, 2007). Also, the consideration of usability principles for mobile Internet applications suggests that mobile learning solutions warrant a specific approach (Uther, 2002a).

The use of mobile based solutions are yet to improve as the lack of infrastructure and limited purchasing power demand not just to develop low-cost approaches and the replicable hardware that can be appropriated and adopted by community-based organizations with minimal requirements for external support (Ho. *et al.*, 2009) but also serve the unique needs of developing regions and populations.

ICT4D: The challenges

In the process of implementing any technological interventions in the context of developing regions, information and communication technologies for development (abbreviated as ICTD or ICT4D) is a study of the relationship between information communication technology (ICT) and development. “It involves multiple sectors—governments, academia, small start-ups, large corporations, intergovernmental organizations, nonprofits, and nongovernmental organizations (NGOs)—and draws interest from multiple disciplines including anthropology, sociology, economics, political science, design, engineering, and computer science” [29].

ICT4D grew in the past decade due in part to the promise of the newer computing technologies; the idea of leapfrogging technology (off-the-shelf solutions) that could be replicated in developing countries poor communities (Toyama and Dias, 2008). But according to Heeks (Heeks, 2008), these efforts (usually the rural telecottage or telecenter) often resulted in failure, restriction, and anecdote, which in turn highlighted the importance of developing sustainable and scalable solutions and interest in objective impact evaluation. Considering the characteristics of physical infrastructure of a developing country (Traxler and Leach, 2006), Heeks (Heeks, 2008) pointed out the need for hardware innovations and develop the type of low-spec, low-cost, low-power consuming robust terminal device and better wireless infrastructure for pushing forward the Internet-connected PC.

“ICT has the connotation of modern electronic technology—the PC, the mobile phone, and the Internet play central roles”(Toyama and Dias, 2008). The development is however a complex social phenomenon (Dearden *et al.*, 2010) and arriving at a definition is far more contentious, and the field of development studies includes a very wide range of positions (Anokwa *et al.*, 2009).

While the mainstream discourse's conceptualization remains heavily focused on economic growth (Kleine, 2009), some on the millennium development goals (MDGs) and some concentrate on people’s livelihoods, and Amartya Sen's capability approach offers a way of thinking about development not as economic growth, but as individual freedom (Anokwa *et al.*, 2009). Sen identifies a range of types of freedom that should be considered: political freedoms (such as freedom of speech and democratic governance), social opportunities (such as education and social mobility), guarantees of transparency (from agents of government and other wielders of power), protective security (health care and other social safety nets), as well as the economic freedom in the form of opportunities and capabilities to earn or create a livelihood. All of these elements contribute to people’s freedom to determine their priorities and to improve the quality of their own lives (Dearden *et al.*, 2010).

Thapa et al. (Thapa and Sæbø, 2011) recent case study explored the role of a locally-initiated so-far successful Nepal Wireless networking Project's (NWNP) to provide opportunities to create social, human, physical, financial, and political capital in the remote communities in the mountain regions of Nepal. One of the important findings was that the political capital, such as government support, political stability, and social inclusion, are core challenges of ICT4D projects. They also highlighted that in order to realize the macro level socio-economic impact, the community people should not only be able to access and assess the information; they should also be able to convert it into relevant knowledge, and to make decisions. At the same time, they should be able to generate local content that can be used for revenue generation activities.

As every aspect of our life in the 21st century is increasingly becoming digital, those without ICTs will be increasingly excluded [1]. In addition to ingenious computing solutions that can a) operate in any conditions, b) over any platform c) with low maintenance needs and no budgetary implications, and d) using limited or intermittent power of the kind that currently fuels our appliances, the product is to be used by people with different understandings of knowledge, culture and the role of technology [2]. Therefore, ICT4Ddemands the understanding the context of a developing country, the existing culture and take into account the significance of the social aspects of any interventions and the subfield HCI4D (human-computer interaction for development) is concerned specifically with the relationship between humans and technology in the context of international development, ranging from lower-level interface design issues to higher-level social interactions [29].

Low-Cost Hardware

There are ongoing efforts focused on developing the type of low-cost device that could work in large numbers of poor communities. Interestingly, regardless of different initiatives targeted for developing worlds, the expectations are not met and low-cost terminal is still a central part of ICT4D [1, (Pal *et al.*, 2009).According to Toyama and Ali, “that’s mainly because the technologies developed for the first world have often been a poor fit in these areas, due to issues of cost, infrastructure, physical environment, and social factors, and there is a need for technology research specially aimed at developing regions” (Toyama and Ali, 2009).

One of the well-known initiative, One Laptop Per Child (OLPC) has failed to take off partly because of the its costs US$200 (£141) to make. According to Kraemer et al. (Kraemer *et al.*, 2009), “it has however motivated the PC industry to develop lower-cost, education-oriented PCs, providing developing countries with low-cost computing options directly in competition with OLPC’s own innovation”.

Recently, the Indian government unveiled yet another cheapest laptop computer, a touch-screen device that will cost US$35 (Halliday, 2010) while the locally developed and open handheld hardware 'Simputer' which was cheaper than $35, yet sold a mere 4,000 units in 2005 and disappeared without a trace (Pal *et al.*, 2009).

Why Copyleft Hardware?

Mobile technology is developing and mobile phones capability and performance is continuously getting better. Now, there are many different devices with different screen resolutions running on different platforms and platforms have been proprietary and scattered. There are a variety of operating systems such as Symbian OS, Microsoft’s Windows Mobile, Linux, iPhone OS and many other proprietary operating systems. According to Hashimi and Komatineni (Hashimi and Komatineni, 2009), supporting standards and publishing APIs would greatly encourage widespread, low-cost development of mobile applications, but none of these OSs have taken a clear lead in doing so. Therefore, the need to support open standards to encourage interoperability of emerging technical solutions is one of the grand challenges (Dearden *et al.*, 2010).

Open-source copyleft platforms are relatively new and have a promising future. Copyleft license guarantees every user has freedom and anyone who redistributes the software and hardware design, with or without changes, must pass along the freedom to further copy and change it(gnu.org, 2008).According to GNU (gnu.org, 2008):

…to copyleft a program, we first state that it is copyrighted; then we add distribution terms, which are a legal instrument that gives everyone the rights to use, modify, and redistribute the program's code, or any program derived from it, but only if the distribution terms are unchanged. Thus, the code and the freedoms become legally inseparable. The “left” in “copyleft” is not a reference to the verb “to leave”—only to the direction which is the inverse of “right”.

As the restricted license of a proprietary devices do not allow using hardware designs freely, the copyleft approach however ensures the design is always open for a complete customization, enhancement or extension, allowing the community to influence its future hardware revisions and there is no end of life for devices as in a proprietary system.

If copyleft approach used, even if the device fails, it can at least ensure that the design can continue to live and be improved in future. But, as Weiss (Weiss, 2008) highlighted, "as it has happened with open source software, though, it may take some years and test cases for legal clarity to emerge in open source hardware". Therefore, while benefits of an open-source software are well established, hardware based on an open-source copyleft designs to support specific need in the developing regions are yet to be seen. Also, Weiss (Weiss, 2008) raised several challenging questions that open source hardware faces such as how would business benefit from open sourcing hardware and who is really going to make their own device?

At the moment, there are limited numbers of such copyleft hardware available. A Linux-based mobile platform Openmoko (http://wiki.openmoko.org/) is a project to create mobile phones with an open software stack. They have so far released the 'Neo 1973' and more recently the 'Neo FreeRunner', for which hardware components were selected based on the requirement of publicly available documentation. There are more than twenty different distributions that can be installed on these mobile phones which give end users the option to choose the one that suits their needs. But, despite this choice, the user experience on these phones is still poor. According to Weiss (Weiss, 2008) using these devices is much appreciated by those with the knowledge of Linux OS running inside these phones. However, even though it is not the powerful hardware available, it highlights the possibilities and benefits of allowing users and developers to transform mobile hardware platforms into unique products to fit the purpose.

The sub US$100 WikiReader (Fig. 1), also by Openmoko, offers an interesting alternative to the phone. The Wikireader is a non-wired mobile device. The Wikireader software platform is open source and freely available. The software is loaded directly from the micro-SD card that stores the content as well. This US$99 handheld device stores the text enabling an offline access and an interface has been designed aiming to provide a simple navigation model.

Initially, it provides the content of Wikipedia (an electronic encyclopedia), which can now be updated to display in fifteen different languages. It allows the software developer to customize or adapt the software and contents as necessary. Most importantly, as these kinds of devices are very limited in functionalities, they may have minimal resale potential. In Nepal's context,

Fig. 2. Ben Nanonote – Qi Hardware

we see this as positive since they would be more likely to be used for learning purposes rather than being stolen or sold. Therefore, "One trick pony" devices can be a safe solution (Camara *et al.*, 2010). Also, for the rural communities with limited ICT experience, a few interaction points on a device can reduce the time it takes for users to familiarize themselves with the device. But most importantly, this may reduce uncertainty.

The Wikireader device has a reflective monochrome display, a scratch resistant tempered glass screen and strong plastic casing for added durability. It runs on two AAA batteries for 12 months in normal usage. Sustaining such cost should not be a hindrance compared to getting to and paying for Internet cafes.

Another promising sub US$100 open copyleft hardware device is the Nanonote (Fig. 2) by Qi Hardware – an ultra-small form factor computing device with 3.0" color TFT display. It has a clamshell design with a QWERTY keyboard but it is designed for thumb-typing. The device is still in its infancy and does not have a built-in wireless capability. At the moment, it is targeted at developers, so that it can be turned into something useful as necessary.

Even though these devices were not designed specifically with ICT4D interest, copyleft approach allows designing and developing the device and the content as necessary. The difficult challenge is however to provide a service that users really need. Successful solutions also need understanding of the contexts, local culture, local practice and political issues. A clear understanding of the motivations and circumstances surrounding mobile device use and adoption from the perspective of the consumers themselves is critical (Sarker and Wells, 2003). Thus, there is a need to understand why a person with no Internet access may want a mobile device and what they will use it for?

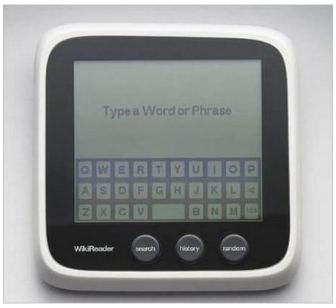

Fig. 1. Interface of the Wikireader

Mobile Learning: Selection of Device

Before proposing, developing and piloting a mobile learning solution, the importance of considering an appropriate target mobile platform to deliver and support learning is one of the key aspects of a sustainable design(Shrestha *et al.*, 2010c). However, mobile learning researchers in every sector and in many countries are focusing on integrating new smart mobile devices (such as iPhone and iPod Touch) into schools and universities and delivering learning resources to meet students' academic needs. But, building applications on these devices mean using the controlled proprietary platform that restricts development.

Most of the recent mobile learning pilots and projects generally relied on provided or loaned smart mobile devices to identify the usefulness of such technologies. An iPhone application such as iStanford (Pena, 2009) from Stanford University was developed to disseminate learning services and also by Curtin University of Technology (Robinson *et al.*, 2009), which has again utilized the iPhone and its subsequent operating system as their platform of choice (Crane and Benachour, 2010).

As part of university initiative to encourage creative usage of technology in education and campus life, Duke distributed 20GB Apple iPod devices to over 1600 entering freshmen in August 2004 (Duke Digital Initiative, 2004). In the fall of 2008, Abilene Christian University became the first university to distribute Apple iPhones and iPod Touches to incoming freshmen of the university, allowing people to explore a new vision for mobile learning (Duke Digital Initiative, 2004).

Similarly, to explore the viability and effectiveness of a mobile teaching and learning environment that would take advantage of mobile phone access to internet instructional materials, iPod touches were provided to students through the college fund (Tien and Boston, 2010). To investigate how best to use mobile technologies in learning and teaching, community of higher educators was formed and the project funded the purchase of iPod touches (Schuck *et al.*, 2010). On the development of a mobile learning portal at University of East London (UEL), currently trails for evaluation are being planned by providing devices with WiFi capability to students through project funding (Olasoji and Draganova, 2010).

Even though applications based on these smart devices may prove to be highly successful, with their choice of exclusive medium, do restrict the amount of penetration in a vast and varying mobile market (Crane and Benachour, 2010). Also, from a developer perspective, developing solutions for a locked down device restricts creative and innovative development (Moore *et al.*, 2009).

However, according to Traxler (Traxler, 2010), mobile learning approach centered on student devices is challenging and radical for institutional IT units. He also highlighted that from a methodological perspective, it is easier with a homogeneous and predictable technology platform and also easier from a staffing and infrastructure perspective since planning and training are comparatively straightforward. It does however mean that most mobile learning pilots and projects are unsustainable because they are predicated on finance in order to provide subsequent cohorts of students with devices (Traxler, 2010). Thus, even though use of the latest mobile technologies can have significant impact on teaching and learning, assessment of the issue of cost in the long term is important to sustain the solutions.

Also, ownership of the technology is equally important in mobile learning. Corlett et al. (Corlett *et al.*, 2005) found that whilst the PDAs were loaned, students were reluctant to invest time and money in personalization and extension. Similarly, from experiences in early pilots, Traxler (Traxler, 2010) suggested that students were not likely to value a second, university-provided device that did not express their taste or aspirations and that it would inevitably be the one left at home.

Some of the current studies also highlighted the issue of affordability, while students were required to pay for the service. StudyTXT (McGuigan*et al.*, 2010) – a SMS based supplementary learning tool within an introductory accounting decision-making course was implemented in order to assist students who may like to download ‘bite-size chunks’ of information prior to the term test and final examination. The most conclusive reason for respondents’ discouragement of StudyTXT’s use was the perceived high cost associated and was a barrier to its widespread usage. Similarly, another study of using SMS to enhance students’ learning experience in the course highlighted the issue of cost that may prevent both the instructor and students from further using it, especially if an interactive mode is adopted (Santos, 2010).

There are also examples of mobile learning studies that have taken similar approach to deliver mobile learning in developing countries. In one of the recent pilot studies in Sri Lanka, a company (Dialog GSM) provided mobile phones to study the use of mobile phone cameras in science teaching and learning, due to schools not having adequate funds to acquire mobile phones for one-to-one use (Ekanayake and Wishart, 2010).

In Bangladesh, the ‘English in Action’ project at its initial phase aims to identify the effective, scalable and sustainable model of supported Open and Distance Learning for English Language Teachers, and the most appropriate forms of mobile technology to support this (Power and Shrestha, 2010). As part of the project, currently teachers from rural schools are being provided iPods to use in the classroom. Such teachers often work in the most challenging situations, with large class sizes, grade repetition, extremely limited teaching resources, poor infrastructure and high exposure to seasonal or environmental strains. However, authors argue the current need to conduct this developmental research is to explore how such technologies can be used to support English language teaching in Bangladesh based on the forecast that mobile technologies will be widely available and affordable, capable of supporting language learning activities and practices, within the next 3 to 6 years.

There are however examples of recent projects in developing countries that throw considerable light on issues of sustainability and scale as the projects face challenges to extend their scope and their impact (Traxler and Leach, 2006). While benefit of mobile learning is clear, developing sustainable solution is still a challenge even in a developed country. According to Traxler, “One over-riding concern is the problem of moving projects and pilots into the mainstream of educational provision and finding secure and sustainable funding and support”. Thus, use of an open platform that can support creativity and provide freedom and unlimited choices for developers and end-users may allow development of cost-effective solutions which will ultimately empower end-users with wider possibilities.

Research Approach

Ubiquitous computing is rapidly expanding and the good understanding of the dynamic nature of existing and upcoming mobile technologies is needed to identify its potential role (Bodker and Buur, 2002). Mobile technologies facilitate the generation of new knowledge, and challenge the notion of education as a modernist meta-narrative and deliver knowledge and information in ways that challenge formal learning (Vavoula *et al.*, 2009). Therefore, the ubiquitous and pervasive nature of contexts or settings in which mobile learning takes place makes it difficult to evaluate and assess its impact.

There are methodological challenges to effectively understand the use of mobile devices and applications (Hagen *et al.*, 2005b). Due to the specific cultural, infrastructural and governmental context of developing countries, applying Mobile HCI

(Human Computer Interaction) research method unchanged is likely to fail (Dörflinger and Gross, 2010). Therefore, Vavoulaet. Al (Vavoula *et al.*, 2009) highlighted that the "western" research approaches and methods are not always relevant and appropriate when studying mobile learning in other parts of the world. According to Toyama and Ali(Toyama and Ali, 2009), the relatively new technical Information Communication Technology for Developing (ICT4D) research lacks appropriate research methods along the entire development life-cycle spanning design, development, deployment, evaluation and monitoring.

Due to limited understanding of users and culture, it is not possible to be certain about the actual value of the technology and how it may be used (Reitmaier *et al.*, 2010). According to (Evans *et al.*, 2008), to develop a sustainable solution and for long-term use and benefits, it is critical to integrate the innovations with the social and cultural practices of the locality. Therefore, this research study is based on the consideration of how well the research tools may work rather than how well they fit within a specific research philosophy.

For the evaluation purpose, selection of the research methods for this study will be based on earlier studies of adoption of mobile technology for learning,(Corlett *et al.*, 2005);(Waycott, 2004). However, as Dearnley and Walker (Dearnley and Walker, 2009) suggested, where possible, flexibility will be built into the study to capture the unique elements of the participants' experience, by not committing to a particular route and regularly reviewing possible approaches to data collection. From the fields of Mobile Human Computer Interaction and Mobile Design research (M-HCI/D), this research will employ various research methodologies to gather and analyze quantitative and qualitative data. Due to exploratory nature of this research, data analysis will be an iterative and reflective process throughout the project.

Pilot Study in Nepal

This research study focuses on providing resources to support teaching and learning English subject which is a part of Nepal's public school's curriculum. To achieve the goal, we will implement the project in three main stages within approximately one year. In future publications, we will present the findings from each stages of our research study.

Stage One: Public schools without an access to ICT

Our initial study will aim at identifying the current challenges in public schools that lack access to ICT. We will conduct an exploratory study involving sixteen English teachers for year 9 and 10 in eight government funded public schools in Chitwan district.All the schools are located in and outskirt of Narayangarh, which is a small town situated 140 km South/west of the capital of Nepal, Kathmandu.We will use a pre-questionnaire and conduct a two weeks long paper based diary study.

Using teachers notes of daily teaching, learning and social activities will help to gain deeper understanding of how they teach and learn, how the courses are structured, what sort of resources are expected and what could be their motivation to adopt mobile technologies to support teaching and learning. We hope that it will help to identify design implications concerning technology in the context of government schools using traditional teaching practices in Nepal and it may also help to design technological intervention that can hopefully scale by being more applicable to a wider range of schools and other learning contexts.But as our study is constrained to time and limited financial resources, there is a limitation on the generalization that could be made on the findings of this study as the schools are located in a relatively developed (urban) part of the country, where supporting teaching and learning in rural area is even more challenging.

Second Stage: Public schools with an access to ICT

With the understanding of ways of teaching and learning, needs and concerns in government schools without an access to ICT, we aim to conducta further study in the public schools supported by Open Learning Exchange(OLE) Nepal[1]. The aim is to investigate how ICT might be helping these schools in teaching and learning and address the challenges identified from the initial study.

OLE Nepal is a non-profit organisation, working towards improving quality and access in Nepal's public education system. The main goal of this organization is to develop and disseminate high quality open-

[1]http://www.olenepal.org/

source ICT-based educational teaching-learning materials that are accessible and available free of cost to all. At the moment, OLE Nepal has connected 28 schools from different parts of the country with its central server, providing online and local access to digital library and also introducing OLPC to participating schools since April 2008.

Third Stage: Intervention Study

Finally, we will explore the opportunities to supplement the existing teaching and learning practices by providing a much needed access to digital resources using low-cost open-source mobile platform. We will provide the offline learning devices with customized contents to selected teachers for three months in our targeted public schools that lack access to digital resources to support teaching and learning. This will help focus on evaluating the usefulness of the proposed solution. The evaluation will adopt an approach recommended by(Sharples, 2009), which is to address usability (will it work?), effectiveness (is it enhancing learning?) and satisfaction (is it liked?).

The teachers will be asked to complete questionnaires at 1, 8 and 12 weeks after they are issued with the devices. They will be asked to indicate the frequency of use of the device and it will help reveal changing patterns of use and interest over the given period of time. Each survey will be followed by an interview to discuss the meaning of the results and also to raise other issues and problems. They will also be asked to complete written logbooks of their daily activities with the device, including the location, duration and type of activity, which will reveal patterns and frequency of use across location during the study period.

Post-questionnaires at the end of the project will address the issues that will arise from the earlier surveys and interviews and will consist of both open and closed questions. The purpose will be to find out what features of the device they had used, whether they had found it to be a useful tool for supporting learning and teaching, what sort of strategies they adopted when using it and what the benefits and limitations were of using the mobile device for offline learning.

Conclusion

A copyleft open-source approach provides the opportunity for the community to directly influence the hardware roadmap of a device and thus may generate new and sustainable solutions within specific markets. This research aims to explore devices such as Wikireader - an unconnected device with a single functionality and the tiny Linux powered hackable device - Nanonote. The main benefit will be giving the users a one-stop access to learning materials at anytime and anywhere without requiring to go online using smart devices.

This study will also highlight the development challenges faced working with a sub US$100 device including usability issues and the lack of a standard graphical user interface. Overall this study will showcase alternative open hardware solutions to more restrictive proprietary solutions which are currently dominating the mobile landscape.

It is however not possible to predict in advance how the teachers will use the unconnected devices or even if they would adopt them at all. However, due to lack of resources in the context of government schools in Nepal, it may be possible to see the clear benefit of use and deduce learning gains due to use of solutions based on such devices.

As the research aims to explore a new technology, our evaluation approach may not show what or how the users will be learning. The ultimate goal is to develop a sustainable solution, a service that users really need by improving the technology, supporting learning and providing a satisfactory user experience which requires understanding of the local context, culture and practice in the context of ICT4D.

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Appendix O (Conference Paper 1): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2010). "Offline Mobile Learning for ICT4D", IADIS International Conference Mobile Learning 2010, Porto, Portugal.

OFFLINE MOBILE LEARNING FOR ICT4D

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ABSTRACT

Poor information infrastructure and higher costs of mobile devices and connectivity in developing country restrict possibilities of providing successful mobile learning (mLearning) services. In the context of Information Communication for Development (ICT4D), this paper aims to highlight the possible role of previously unexplored open platforms for delivering affordable and sustainable mobile learning offline. Based on thorough analysis of current tools, technologies and research, this paper discusses considerable challenges to support an offline scenario. The major technical issues are constrained locked-down hardware and proprietary software. While open platforms can overcome such problems, this paper points out the need for a broader study to investigate its potential role in developing countries.

KEYWORDS

Mobile learning, open-source, copyleft hardware, offline learning, ICT4D.

1. INTRODUCTION

Developing countries do not have proper infrastructure in place to deliver mobile services. ICT and Internet connectivity is nearly non-existent in rural areas of developing countries. When it is available in urban areas it is decidedly inferior to the service in developed countries (UNCTAD 2005). Therefore, the gap exists (digital divide) between those with ready access to the tools of ICT and the benefits that such access brings, and those without such access or skills (Cullen 2001).

But mobile access to digital content is improving and it is already playing a central role in bridging the digital divide. There are examples of how simple handsets and networks are beginning to produce indispensable services such as M-PESA (Hughes & Lonie 2007) in Kenya and Healthline (Rahman 2007) in Bangladesh. However, to fully utilize this potential it is imperative to explore the factors that determine mobile telecommunications development in the developing world (Ping & Adnan 2009). We believe delivering such services on open hardware and open software not just practically make sense but can also lower the cost and thus increase the possibility of offering sustainable services in the future.

This paper consists of four main parts. The first part introduces the concept of mobile learning. The second part looks at how current and upcoming web technologies are supporting offline access to information. The third part examines the recent research on offline mobile learning and the final part will focus on open platforms and their possible use.

2. Mobile learning

Mobile learning (M-learning) is a relatively new research area and it uses mobile technology to facilitate learning. It is a field whose practice has not yet been standardized in terms of research frameworks, methods and tools (Vavoula & Sharples 2009). Moreover, the learning material is often developed with proprietary specifications, preventing content from being shared and reused (Nakabayashi et al. 2007). Also, the consideration of usability principles for mobile Internet applications suggests that mobile learning solutions warrant a specific approach (Uther 2002).

Mobile education application models can be classified into three categories: 'permanently online', 'frequently online' and 'offline' and they bear their own advantages and disadvantages (Qian & Nan 2008). Authors identified applications of permanently online mobile education rely on the wireless network, and to most learners permanently online is hard to achieve and not necessary. They also suggested offline mobile learning with no interaction with servers is also not acceptable. But, one of the important challenges of broad areas for mobile computing is building applications that deal with the arbitrary disconnected nature of mobility, i.e. offline (Yang 2000). In a developing country, offline mobile education has broad application scope, as it will minimize the complexities of providing mobile learning by not having to deal with networking issues, malleability of design and content, simplicity and no steep learning curve.

3. Web technology: offline perspective

Mobile learning connectivity can vary from 'always-on' to 'haven't got any' (Traxler 2005). Online mobile services rely on mobile networks and web applications are usually not capable of dealing with often disconnected nature of mobile devices. Also, there are a variety of mobile devices with capabilities that vary device to device. This creates a problem from an application developers' perspective when it comes to developing native applications. An application running from a web browser may provide a solution, but the analysis of the comparison between desktop and mobile phone web browsing shows a consistent user experience across desktop and mobile devices is hard to achieve (Shrestha 2007). However, web browser features are being extended to create one rich platform for web application development. For example, Mozilla[1] has released Prism - a system for running web applications offline, and Weave - a data storage framework which aims to integrate services more closely with the browser. In addition, Google Gears[2] plug-in can be used on websites to let users access information offline or provide content based on users geographical location. So far, it is only available for limited devices and it also requires users to manually change between modes.

Usually mobile browsers have limited implementation of the Document Object Model and CSS. But HTML5 aims to offer a built-in offline data storage to store current state on the client-side. But, even though it may offer a standardized way for the browser to support offline access without plug-ins, it is also limited to newer browsers. It is also necessary to look into important security issues of browsers while storing data offline. It is still a draft specification and the full impact of this new architecture isn't clear yet. However, Google recently demonstrated a new version of Gmail for mobile that leverage HTML5 and runs on any Android phone in addition to the iPhone or iPod Touch with Apple's 2.2.1 firmware or later. It has been developed using one code-base for web and runs on both platforms. In future, such advancements of web technology may result in a proliferation of applications that run across all the different platforms. However, they will be limited to the devices that support browsers capable of handling HTML5.

4. Related work

The development of an offline system for mobile learning is materially different than the development of off-line e-learning (Georgiev et al. 2006) It is also difficult to transfer all types of LMS (Learning Management Systems) to mobile handsets due to the fact that both the hardware and software on mobile handsets have inherent limitations in running a multi-functional LMS (Wang & Higgins 2008). Nakabayashi et al. (2007) highlighted the inability of native (built-in) browsers to deal with a script language and therefore developed a general-purpose offline content browsing function to enable offline learning using mobile phones. Similarly, Trifonova & Ronchetti (2004) proposed a mobile adapter that adapted services for accessing through mobile devices that can be used both online and offline. As making mobile browser an open standardized tool is an enormous challenge, authors recognized the need to implement multiple content browsers considering variation in capabilities of mobile devices.

Moore et al. (2009) explored capability of the iPhone as an offline learning tool. The goal of the software was to allow documents to be located during an Internet search and then cached on the

[1]https://mozillalabs.com
[2]http://gears.google.com

device to be read offline. To facilitate offline access to these documents a powerful open source search engine was ported to mobile architectures. This provided an efficient method of locating documents using familiar keyword searches which scaled beyond traditional file browser approaches. In addition, it allowed documents to be easily located despite having ambiguous file names. The authors faced significant challenges during development which required "jail breaking" the device. Thus, although storing, searching and accessing documents locally demonstrates potential for a powerful offline tool, developing solutions for a locked down device restricts creative and innovative development.

The iPhone has the advantage of having a truly innovative multi-touch interface, however, only open platforms can provide unlimited choices for developers and ultimately for end-users. In addition, within the context of ICT4D, inexpensive platforms can facilitate rapid application development (Ledlie et al. 2009). Thus it is important to consider cost-effective alternative platforms to high end mobile devices such as the iPhone.

5. Open platforms

Mobile phones have become full-featured mobile computers. There are many different devices with different screen resolutions running on different platforms. Previously, platforms have been proprietary and scattered. There are a variety of operating systems such as Symbian OS, Microsoft's Windows Mobile, Linux, iPhone OS and many other proprietary OSs. Supporting standards and publishing APIs would greatly encourage widespread, low-cost development of mobile applications, but none of these OSs have taken a clear lead in doing so to (Hashimi & Komatineni 2009).

As the premise of an open source mobile phone OS has become reality, it makes interfacing with nonstandard and alternative hardware easier. A Linux-based mobile platform project such as Openmoko[3] is available now which applies the open source concept to hardware. They have so far released the 'Neo 1973' and more recently the 'Neo FreeRunner'. There are more than twenty different distributions that can be installed on these mobile phones which gives end users the option to choose the one that suits their needs. Despite this choice the user experience on these phones is still poor. However, even though it is not the latest or best hardware available, it can still be customised to fit the purpose in developing countries. Open platforms are relatively new and their quality is expected to improve through community effort. The sub $100 WikiReader, also by Openmoko, offers an interesting alternative to the phone. It can run on a pair of AAA batteries for a whole year and has been designed to be viewable in sunlight. Another promising sub $100 open copyleft hardware device is the Nanonote[4] – an ultra-small form factor computing device with 3.0" colour TFT display. The open hardware approach taken by these companies is expected to allow the community to influence its future hardware revisions and devices.

Open devices have a promising future. Once they become cheaply available, they may have real scope in the ICT4D context. They can help introduce the idea of a 'One Mobile per Child' which will be affordable and realistic and serve as an alternative to expensive 'One Laptop Per child' idea. It may need a heavy investment but mobile roll out would be cheaper than creating a fixed line infrastructure. Even though GPRS/3G networks and handsets are coming down in cost, common use of expensive smart phones such as the iPhone in ICT4D context is not yet possible. The cost of the device is one important factor and US$100 per laptop is also an expensive solution (Chhanabhai & Holt 2009). But, the most difficult challenge is to provide a service that users really need. Successful solutions also need understanding of the contexts, local culture, local practice and political issues. A clear understanding of the motivations and circumstances surrounding mobile device use and adoption from the perspective of the consumers themselves is critical (Sarker & Wells 2003). Thus, there is a need to understand why a person with no Internet access may want a phone and what they will use it for?

6. Conclusion

[3]http://www.openmoko.com/

[4]http://www.qi-hardware.com/products/ben-nanonote/

Considering the poor infrastructure and higher costs of devices and connectivity in the developing world, this research discussed the potential role of open platforms to support offline mobile learning. The paper reviewed how current technologies provide offline access and analyzed the challenges of delivering mobile learning offline. Total cost of mobile devices and their associated services is one major concern. Open technologies might provide the tools developers' need to revolutionize the mobile industry. However, identifying their place in the global ICT4D picture and proving their worthiness remains a challenge. Only by evaluating users' needs specific to such technologies and creating products that successfully address those needs will it be possible to achieve satisfactory user experiences.

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Appendix P (Conference Paper 2): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2010)."Sustainable Mobile Learning: Open & Offline", mLearn 2010, Malta.

Sustainable Mobile Learning: Open & Offline

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Abstract
The main aim of our research is to explore the use of Wikireader as a potential tool to provide an affordable and sustainable offline mobile learning solution. We will evaluate the usability of Wikireader and validate the concept of an offline mobile learning approach by conducting a pilot study in Thames Valley University, UK. In this paper, we try to understand the importance of considering an appropriate target mobile platform as a key aspect of a sustainable design to deliver and support learning. We also analysed the data collected at the early stage of the pilot study and our result indicates a lack of high-end or 'smart-phones' among students and therefore supports our cost-effective approach to mobile learning.

Keywords
ICT4D, offline mobile learning, open-source, copyleft hardware, Btlogger, Wikireader.

1. BACKGROUND: MOBILE LEARNING

Mobile learning (M-learning) is a relatively new research area and it uses mobile technology to facilitate learning. It is a field whose practice has not yet been standardized in terms of research frameworks, methods and tools (Vavoula and Sharples, 2009). Moreover, the learning material is often developed with proprietary specifications, preventing content from being shared and reused(Nakabayashi et al., 2007). Also, the consideration of usability principles for mobile Internet applications suggests that mobile learning solutions warrant a specific approach(Uther, 2002b).

Mobile education application models can be classified into three categories: 'permanently online', 'frequently online' and 'offline' and they bear their own advantages and disadvantages (Qian and Nan, 2008). Authors identified applications of permanently online mobile education rely on the wireless network, and to most learners permanently online is hard to achieve and not necessary. They also suggested offline mobile learning with no interaction with servers is also not acceptable. But, one of the important challenges of broad are as for mobile computing is building applications that deal with the arbitrary disconnected nature of mobility, i.e. offline (Yang, 2000).

Considering the difficulties and challenges of delivering a successful mobile learning, we propose an offline mobile learning solution (Shrestha et al., 2010a) using the Wikireader1device to deliver learning. We plan to evaluate the usability of the Wikireader and validate the concept of an offline mobile learning approach by conducting a pilot study in Thames Valley University, UK.

Next, we will discuss the selection of a mobile platform by some of the recent pilots and projects and present the rationale for choosing the Wikireader device. Then, we will provide an insight into the trends of use of mobile devices in Thames Valley University, based on data collected using Btlogger[2] Bluetooth software and finally draw a conclusion by reflecting on our approach to mobile learning.

2. SELECTION OF DEVICE

Before proposing, developing and piloting a mobile learning solution, the importance of considering an appropriate target mobile platform to deliver and support learning is one

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[1] http://thewikireader.com/
[2]http://gitorious.org/btlogger/

of the key aspects of a sustainable design. However, mobile learning researchers are focusing on integrating expensive new smart mobile devices (such as iPhone and iPod Touch) into schools and universities and delivering learning resources to meet students' academic needs. But, building applications on these devices mean using the controlled proprietary platform that restricts development.

Most of the recent mobile learning pilots and projects generally relied on provided or loaned smart mobile devices to identify the usefulness of such technologies. An iPhone application such as iSanford (Pena, 2009) from Stanford University was developed to disseminate learning services and also by Curtin University of Technology, (Robinson et al., 2009), which has again utilized the iPhone and its subsequent operating system as their platform of choice (Crane and Benachour, 2010).

As part of university initiative to encourage creative usage of technology in education and campus life, Duke distributed 20GB Apple iPod devices to over 1600 entering freshmen in August 2004 (Duke Digital Initiative, 2004). In the fall of 2008, Abilene Christian University became the first university to distribute Apple iPhones and iPod Touches to incoming freshmen of the university, allowing people to explore a new vision for mobile learning (Li et al., 2010).

Similarly, to explore the viability and effectiveness of a mobile teaching and learning environment that would take advantage of mobile phone access to internet instructional materials, iPod touches were provided to students through the college fund (Tien and Boston, 2010). To investigate how best to use mobile technologies in learning and teaching, community of higher educators was formed and the project funded the purchase of iPod touches (Schuck et al., 2010).On the development of a mobile learning portal at University of East London (UEL), currently trails for evaluation are being planned by providing devices with WiFi capability to students through project funding (Olasoji and Draganova, 2010).

Even though applications based on these smart devices may prove to be highly successful, with their choice of exclusive medium, do restrict the amount of penetration in a vast and varying mobile market (Crane and Benachour, 2010). Also, from a developer perspective, developing solutions for a locked down device restricts creative and innovative development (Moore et al., 2009).

However, according to Traxler (2010), mobile learning approach centred on student devices is challenging and radical for institutional IT units. He also highlighted that from a methodological perspective, it is easier with a homogeneous and predictable technology platform and also easier from a staffing and infrastructure perspective since planning and training are comparatively straightforward. It does however mean that most mobile learning pilots and projects are unsustainable because they are predicated on finance in order to provide subsequent cohorts of students with devices (Traxler, 2010).Thus, even though use of the latest mobile technologies can have significant impact on teaching and learning, assessment of the issue of cost in the long term is important to sustain the solutions.

Also, ownership of the technology is equally important in mobile learning. (Corlett *et al.*, 2005) found that whilst the PDAs were loaned, students were reluctant to invest time and money in personalization and extension. Similarly, from experiences in early pilots, Traxler (2010) suggested that students were not likely to value a second, university-provided device that did not express their taste or aspirations and that it would inevitably be the one left at home.

Some of the current studies also highlighted the issue of affordability, while students were required to pay for the service. StudyTXT (McGuigan*et al.*, 2010) – a SMS based supplementary learning tool within an introductory accounting decision-making course was implemented in order to assist students who may like to download ‘bite-size chunks’ of information prior to the term test and final examination. The most conclusive reason for respondents’ discouragement of StudyTXT’s use was the perceived high cost associated and was a barrier to its widespread usage. Similarly, another study of using SMS to enhance students’ learning experience in the course highlighted the issue of cost that may prevent both the instructor and students from further using it, especially if an interactive mode is adopted (Santos, 2010).

There are also examples of mobile learning studies that have taken similar approach to deliver mobile learning in developing countries. In one of the recent pilot studies in Sri Lanka, a company (Dialog GSM) provided mobile phones to study the use of mobile phone cameras in science teaching and learning, due to schools not having adequate funds to acquire mobile phones for one-to-one use, (Ekanayake and Wishart, 2010).

In Bangladesh, the ‘English in Action’ project at its initial phase aims to identify the effective, scalable and sustainable model of supported Open and Distance Learning for English Language Teachers, and the most appropriate forms of mobile technology to support this (Power and Shrestha, 2010). As part of the project, currently teachers from rural schools are being provided iPods to use in the classroom. Such teachers often work in the most challenging situations, with large class sizes, grade repetition, extremely limited teaching resources, poor infrastructure and high exposure to seasonal or environmental strains. However, authors argue the current need to conduct this developmental research is to explore how such technologies can be used to support English language teaching in Bangladesh based on the forecast that mobile technologies will be widely available and affordable, capable of supporting language learning activities and practices, within the next 3 to 6 years.

There are however examples of recent projects in developing countries that throw considerable light on issues of sustainability and scale as the projects face challenges to extend their scope and their impact(Traxler and Leach, 2006). Therefore, in the context of developing country, it is consideration of cost-effective alternative platforms to high end mobile devices is also important (Shrestha et al., 2010a).

While benefit of mobile learning is clear, developing sustainable solution is still a challenge even in a developed country. One over-riding concern is the problem of moving projects and pilots into the mainstream of educational provision and finding secure and sustainable funding and support(Traxler and Leach, 2006). Thus, use of an open platform that can support creativity and provide freedom and unlimited choices for developers may allow development of cost-effective solutions which will ultimately empower end-users with wider possibilities.

3.WIKIREADER

The Wikireader is a non-wired mobile device. The Wikireader software platform is open source and freely available. The software is loaded directly from the micro-SD card that stores the content as well. This US$99 handheld device stores the text enabling an offline access and an interface has been designed aiming to provide a simple navigation model.

Initially, it provides the content of Wikipedia (an electronic encyclopaedia). But it allows the software developer to customise or adapt the software and contents as necessary. Most importantly, as these kinds of devices are very limited in functionalities, they may have minimal resale potential. We see this as positive since they would be more likely to be used for learning purposes rather than being stolen or sold. "One trick pony" devices can be a safe solution. Also, for the rural communities with limited ICT experience, a few interaction points on a device can reduce the time it takes for users to familiarise themselves with the device. But most importantly, this may reduce uncertainty.

The device has a reflective monochrome display, a scratch resistant tempered glass screen and strong plastic casing for added durability. These form factors are some of the rationales for opting for Wikireaders. It runs on two AAA batteries for 12 months in normal usage. Sustaining such cost should not be a hindrance compared to getting to and paying for Internet cafes.

Also, because the device is an open platform, it would be expected that the community of developers would influence its future hardware and software revisions and potentially increase distribution and thus reduce costs. In addition, Wikireader developers' open source community also provides technical support to all interested parties to build customized content for the devices.

4.PILOT STUDY

The project will be piloted with content from the Mobile Application Development module which is part of the MSc Network and Mobile Computing course. We will have a small group of full-time students taking this module and be part of our pilot study.

We initially surveyed the mobile usage of our postgraduate students. We collected information about their choice of phone, payment plans, and mobile internet usage including their personal usage of university’s virtual learning environment. Before undertaking the pilot study, we also wanted to investigate what devices are generally used in the university’s campus. Therefore, we used Btlogger to collect data from discoverable Bluetooth devices.

a) Students Survey

Our Masters programmes attract a large cohort of students from India. These students can have difficulties adapting to a UK university learning environment. They also have limited access to ICT resources outside the university.

We have sixteen students currently registered for the MSc Network and Mobile Computing course, who will participate in our pilot study. The age of participants varies from 18 to 25 years and all the students are male. They all have modest to high desktop computer experience and use internet every day or almost every day. Nine of the students have different range of Nokia phones from 1600, 2323c and 6303. Four students own Sony Ericsson phones, one has a Samsung and two of the students own iPhone. Out of sixteen, only three has contract and the rest are on ‘pay as you go’ including both iPhone users.

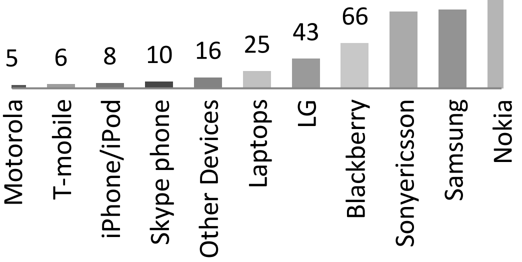
Out of sixteen, one has an average mobile using experience and fourteen students have a good experience. Eleven of these students have no experience of web browsing on mobile phones as well. Other five participants have limited mobile web browsing experience. All the students use their mobile phones mostly for making calls and text messaging.

When asked why they do not use mobile for web browsing, students are very concerned about the cost. Some of them also have devices that do not support web browsing and some do not need to use mobile phone for browsing as desktop use is sufficient for them. None of the students have ever seen or used Wikireader before. However, they have all said it will be beneficial to provide uninterrupted access to learning materials using Wikireader while avoiding the need for Internet access via mobile phones.

b) Btlogger

Btlogger is an open-source and simple Bluetooth to Sqlite logger software than can also post results to Twitter. The tweeting feature helped us monitor an overall data collection process and also allowed us to share the results live as we want to be as open as possible. An important feature of this software is, when it discovers the previously found devices, it updates the same device in the database and avoids any duplication of data. The software works on any Linux system with Bluetooth.

Figure 1: The penetration of mobile devices on



Thames Valley University’s Ealing campus

In our study, Btlogger logged a total 1295 discoverable Bluetooth devices over 8 months between 7thSeptember 2009 and 10th May 2010 in the University’s Ealing Campus. Usually Bluetooth broadcast is disabled by default on mobile devices and this software relies on only those devices with Bluetooth on. Also, due to users personalizing the default name of the devices, manufacturer details of 54% of the logged devices could not be recognized. However, the remaining 46% of the logged devices gave us a useful indicator to the current trend of mobile use in our university campus which is presented here.

The graph shows (see Figure 1) 32% of devices have been Nokia devices, about 19% of Samsung and Sony Ericsson, and 7% of LG devices and 11% Blackberry. With only 1% of the iPhone/iPod share, it shows only a small percentage potentially use such smart devices in our university. Similar previous research study (Larsen et al 2004) within the Lancaster University campus also showed the lack of high-end or smart-phones penetration.

With a diverse range of devices available which correspond with the mobile user’s needs and budgets; creating a solution which works successfully for a range of different manufacturers and models would be difficult (Crane and Benachour, 2010). Also, even though the low-end phones are stable and widely available, they are not capable of supporting smart learning applications.

5. CONCLUSION

With the lack of high-end or ‘smart-phones’ in the investigation, our findings highlight the difficulty of developing a sustainable mobile learning solution in our university. Therefore, our research focuses on developing for more cost-effective (under US$100) open platforms that support customized content for learning purpose.

At this stage, it is not possible to predict in advance how the students in our University will use the unconnected Wikireader devices with limited functionality that do not offer an interactive or media-rich learning experience or even if they would adopt them at all. Our ultimate goal is to develop a successful solution, a service that users really need by improving the technology, supporting learning and providing a satisfactory user experience at the same time.

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Appendix Q (Conference Paper 3): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2011). "Flexible learning with flexible devices: opening up opportunities", mLearn 2011, Beijing.

Flexible learning with flexible devices: opening up opportunities

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ABSTRACT

This paper reports on an action research study of students' exploration and use of previously unexplored low-spec sub US$100 open-source mobile devices for learning programming. The study was conducted over a period of fourteen weeks in University of West London, UK with the postgraduate students studying Mobile Application Development (MAD) module which is a part of the MSc Network and Mobile Computing course. We introduced the Wikireader, a handheld reading device and Nanonote, a lightweight pocket computer, developed using a copyleft approach. In this study, we used mixed methods research methodology. Data analysis was guided by the Framework for the Rational Analysis of Mobile Education (FRAME) model. From the results of our evaluations, we were not able to ascertain whether or not these devices improved learning programming. However, the findings indicate these open-source devices have potential to enhance motivation to learn programming without being restricted to the limited practical sessions in the university lab and also facilitate offline reading.

Author Keywords

Copyleft Hardware, Offline Mobile Learning, Nanonote, Wikireader, Open-source Technology, Mobile Usability.

INTRODUCTION

Learning programming is not easy and there is no shortcut in learning to program (Hassinen and Mäyrä, 2006);(Sheard *et al.*, 2009). Generally, the learning approach is based around lectures on specific topics, followed by tutorial / practical sessions on applying the lecture content to specific case studies. “Programming language concepts are highly logical and therefore difficult to understand by conventional study materials” (Patil and Sawant, 2010). Even though the traditional approach of concepts first is common, students struggle to learn program due to lack of extensive hands-on practice and sufficient time to become familiar with programming concept. Therefore, a clearer approach to teaching programming is needed (Milne and Rowe, 2002) and research has shown a learner-centred approach to teaching programming is effective and successful (Moura, 2011).

In this exploratory pilot study, our focus is on the low-spec sub US$100 open-source handheld mobile devices. As the cost of hardware reduces we are beginning to reach a point where it will become possible to replace a USB flash storage device in your pocket with a small computer. This style of ubiquitous computing provides some interesting learning opportunities but also poses significant technical and usability challenges.

This paper reports on an empirical study of the deployment of Nanonote and Wikireader for learning programming with the group of twelve students studying MSc Mobile and Networking. Our aim was to evaluate the usefulness of devices in teaching and learning by assessing its usability, probing how students used such devices and identifying problems while learning programming and provide support throughout the study period.

We begin by reviewing the context of programming education and benefits of introducing mobile devices to support learning. Then, we highlight the open-source copyleft approach, possible benefits of such approach to software and hardware designs and introduce the Wikireader and Nanonote devices. Next, we discuss the research methodology and elaborate on the research approach we used in this pilot study. Finally, based on the FRAME model for mobile learning, we analyse our findings and conclude by reflecting on our results and the overall study.

LEARNING PROGRAMMING USING MOBILE DEVICES

“Mobile application development requires a considerably different approach compared to applications for the desktop computers and need the understanding of the complexity of their operating environment, which is much less predictable than contemporary fixed wire networks, and the restrictions placed by the devices themselves in terms of memory, power, speed, screen size, etc.” (Edwards and Coulton, 2007). Therefore, it is important to encourage students to gain practical skills to develop applications with the understanding of the existing limitations of the mobile platforms that a developer faces daily. Introducing mobile devices at an early stage in the computer science curriculum can improve students' learning (Mahmoud and Popowicz, 2010) as a use of hands-on oriented approach in introductory programming courses has shown increase in a positive experience (Kulkarni, 2010); (Richards and Smith, 2010).

Bruhn and Burton (Bruhn and Burton, 2003) studied the use of computers in the classroom to help students to better understand programming concepts during classroom presentations. Even though this approach helped the average-to-poor students' achievers the most, it needs more time to present the material to the students and it also takes time for students to practice programming concepts on the computer in class. Research shows that only through adequate practice and training can expertise be obtained in the field of programming (Bruhn and Burton, 2003);(Ala-Mutka, 2004) and thus learning should go beyond classroom/lab environment.

Some of the proposed approaches to teaching computer programming are using robotics or through the use of game design and using mobile devices (Mahmoud and Popowicz, 2010).Introduction of mobile devices in programming education provides the practical development experience students need and students appreciate the unique opportunities mobile devices offer and also become aware of the development challenges they present (Mahmoud and Dyer, 2008);(Mahmoud and Popowicz, 2010). However, the analysis of research papers about programming education published in computing education conferences identified only few studies that considered online distributed or mobile learning in programming education(Sheard *et al.*, 2009). Therefore, we approached teaching programming by using mobile devices to provide relevant programming knowledge and these devices can also be used for hands-on practices. At the time of this review, we were not aware of research studies that explored open-source platforms particularly the Nanonotes and Wikireaders in such programming education context.

COPYLEFT APPROACH

Mobile technology is developing and mobile phones capability and performance is continuously getting better. Now, there are many different devices with different screen resolutions running on different platforms and platforms have been proprietary and scattered. There are a variety of operating systems such as Symbian OS, Microsoft's Windows Mobile, Linux, iPhone OS and many other proprietary operating systems. According to Hashimi and Komatineni(Hashimi and Komatineni, 2009), supporting standards and publishing APIs would greatly encourage widespread, low-cost development of mobile applications, but none of these OSs have taken a clear lead in doing so. Therefore, the need to support open standards to encourage interoperability of emerging technical solutions is one of the grand challenges (Dearden *et al.*, 2010).

The emergence of "app stores" provide a platform where small applications are exchanged for small amounts of money without any requirement to share code. We believe in an approach which encourages sharing of knowledge and therefore believe in using mechanisms such as copyright law to enforce this approach. The approach is known as "copyleft". Open-source copyleft platforms are relatively new but have a promising future. Copyleft license guarantees every user has freedom and anyone who redistributes the software and hardware design, with or without changes, must pass along the freedom to further copy and change it. According to GNU, "the "left" in "copyleft" is not a reference to the verb 'to leave'—only to the direction which is the inverse of 'right'". As the restricted license of a proprietary devices do not allow using hardware designs freely, the copyleft approach however ensures the design is always open for a complete customization, enhancement or extension, allowing the community to influence its future hardware revisions and there is no end of life for devices as in a proprietary system. If coplyleft approach used, even if the device fails, it can at least ensure that the design can continue to live and be improved in future.

We believe solutions that use a copyleft approach not only give freedom to the software developer, they also provide an opportunity for the community to directly influence the hardware roadmap of a device and thus generate possibilities for creating new and sustainable solutions within specific markets.

The sub US$100 WikiReader (see Figure 1a), by Openmoko, offers an interesting alternative to the phone for supporting mobile learning. The Wikireader is a non-wired mobile device. Its software platform is open source and freely available. Initially, it provides the content of Wikipedia (an electronic encyclopaedia), which can now be updated to display in eighteen different languages. It allows the software developer to customize or adapt the software and contents as necessary. Another promising sub US$100 open copyleft hardware device is the Nanonote (see Figure 1b) by Qi Hardware. It is an ultra-small form factor computing device with 3.0" color TFT display. It runs embedded Linux distribution (OpenWrt, which is usually found in Wifi routers) and uses a kernel, bootloader and root file system that can be flashed over the USB port. The device is however still in its infancy and does not have a built-in wireless capability. The device is not designed to be mass marketed consumer electronic product and at the moment, it is targeted at developers, so that it can be turned into something useful as necessary.

Figure 1a.Wikireader – offline handheld reading device. Figure 1b. Ben Nanonote - an ultra-small form factor copyleft computing device which has 336 MHz XBurst CPU, 3.0” display and 2GB NAND flash memory.

While benefits of open-source software are well established, consumer hardware based on an open-source copyleft designs are yet to be seen. Weiss (Weiss, 2008) highlighted, “as it has happened with open source software, though, it may take some years and test cases for legal clarity to emerge in open source hardware”. Therefore, there are also several challenging questions that open source hardware faces such as how would business benefit from open sourcing hardware and who is really going to make their own device? (Weiss, 2008)

Research methodology

In this study, we took an action research approach. The basic premises of an action research paradigm are that the research is “participative, grounded in experience, and action-oriented” (Reason and Burgess, 2001 p.xxiv in (Lunsford, 2010). The students’ participation helped not only to evaluate the devices but also to understand the problems they faced while learning programming and provide the necessary support during the study. Similar to Lunsford research work at the Open University (Lunsford, 2010), the goal was also to disseminate the findings within the University for the wider use of other staffs and students that could lead to possible changes in practice.

For the evaluation purpose, selection of the research methods for this study was based on earlier studies of adoption of mobile technology for learning by Corlettet al. (Corlett *et al.*, 2005) and Waycott (Waycott, 2004). To capture the unique elements of the participants’ experience, where possible, flexibility was built into the study by not committing to a particular route and regularly reviewing possible approaches to data collection (Dearnley and Walker, 2009). From the fields of Mobile Human Computer Interaction and Mobile Design research (M-HCI/D), this research employed mixed research methodology, which is the most common approach used in programming education research (Sheard *et al.*, 2009), to gather and analyse quantitative and qualitative data on mobile learning and usability. Due to exploratory nature of this research, data analysis was iterative and reflective process throughout the study. The data was examined in relation to the Framework for the Rational Analysis of Mobile Education (FRAME) model, which is discussed next.

Framework for the Rational Analysis of Mobile Education (FRAME) model

Research shows the lack of specific models for teaching and learning of programming and research studies that investigated learning within a theoretical framework to explore the process of learning (Sheard *et al.*, 2009), which is important to deepen our understanding of students' behavioural or affective responses to their learning or teaching experience. We adopted the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2009) to study the feasibility of open-source platforms for teaching and learning programming.

"The FRAME model describes mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction" (Koole, 2009); (Koole and Ally, 2006). There are set of three intersecting circles representing the device (D)which describes characteristics unique to electronic, networked mobile technologies; learner (L)describes characteristics of individual learners; and social (S) aspects describes the mechanisms of interaction among individuals (Koole and Ally, 2006).

The overlapping intersection of the FRAME model representing the device usability (DL) and social technology (DS) describe the affordances of mobile technology; the interaction learning (LS) contains instructional and learning theories and the primary intersection (DLS) in the centre is a convergence of all three aspects, defines an ideal mobile learning situation (Koole, 2009). As we were introducing a new technology, the main focus of our pilot study was in the device (D) and the learner (L) aspects and its intersection device usability (DL).

The low-spec Wikireader and Nanonote devices are not equipped with various technical capabilities, such as short messaging service (SMS), telephony, and access to the Internet through wireless networks. Therefore, these devices do not enable active communication between the students and tutor. Nevertheless, we wanted to maintain the existing culture of physical and virtual cooperation and communication between students' and tutor in the classroom, lab and through Blackboard virtual learning environment and facilitate learning by introducing these devices (Koole, 2009). Students were also encouraged to engage in problem solving activities and where possible exchange knowledge and collaborate. It is however important to fully explore the social technology and interaction aspects of using mobile devices which are important to fully utilize the affordances of the devices especially in the context of mobile distance education and blended learning (Kenny *et al.*, 2009b).

PILOT STUDY: BACKGROUND

The pilot study was carried out in University of West London with a small group of twelve full-time students studying Mobile Application Development (MAD) module which is a part of the MSc Network and Mobile Computing course. This module has been developed to provide hands-on experience developing software for mobile devices using an open source approach to software development and students are expected to gain experience using relevant industry standard tools to support their work. The organization of this study and the data collection was completed in four months starting September 2010.

The Module: Mobile Application Development (MAD)

The MAD module is delivered over the period of fourteen weeks and provides three hours of class contact per week. One hour for a formal lecture and two hours of practical lab classes. There are two parts in this module. First seven weeks focus on the use of C Programming language and in the other half; students use the higher-level programming language building on the experience from what they learned from the first seven weeks.

To pass this module, students are required to submit two assignments in seventh and the fourteenth week which is the end of the term. Both assignments have one element each which required developing a command-line application that is capable of communicating structured binary data across a TCP/IP network and suitable for deployment on a Linux based embedded device. As it is important to gain some experience designing and structuring binary network protocols, students are introduced to the Packedobjects - a data encoding tool that provides high-level bit-packing on low-level devices (Moore, 2010).

Study Approach

The first part of the module was taught using combination of lecture and practical class where students had hands-on experience of programming in the lab. But on the second part of the module, they were also given Nanonote and Wikireader devices to take away and use until the end of the term. The students were not trained specifically to use these devices, as they were expected to explore and use the devices to support learning programming.

At the beginning, we obtained the written informed consents from the students who agreed to participate in this study and administrated the pre-questionnaires and analysed the demographics. Then students randomly selected the devices, so that the six students had Wikireaders and other six had Nanonotes. As prerequisite, the students were expected to be familiar with some programming and Linux desktop environment and where available, they were also encouraged to setup Linux system in their personal machines.

As the students were studying other two modules as part of the MSc course and busy with assignments, we realized the data collection techniques have to be simple and this study should not be felt as a burden to them instead of our goal of providing support for learning. Therefore, even though we initially planned to use the diary study method, students were requested to keep the log of their activities instead. Research shows that diary study method can suffer from the drawback of potentially missing data, because participants may forget to record entries or are selective in reporting (Bolger and Davis, 2003), and also possible that they may find it difficult to write unprompted (Hall, 2008). In the activity log, students simply recorded *when? where? why?* They used the devices and documented if they found them useful and also record the problems or difficulties they faced. The simple log provided an effective way to monitor progress and also identify learning issues early and provide appropriate support.

Finally, post-test questionnaire at the end of the study was used to find out what features of the device the students had used and whether they had found it to be a useful tool for supporting learning and what the benefits and limitations of the technologies were. The activity logs were also used in a supplementary manner which helped to further understand the students' view that they expressed in the post-test questionnaires.

Device Aspect (d)

According to Kenny et al (Kenny *et al.*, 2009b) mobile learning is constrained by the mobile device hardware and software configurations and dependent upon adjustments in teaching and learning strategies. While benefit of mobile learning is clear, developing sustainable solution is still a challenge, as the mobile industry is dominated by proprietary technologies and this situation is mirrored throughout academia(Shrestha *et al.*, 2010c). Therefore, even though the use of the latest mobile technologies can have significant impact on teaching and learning, assessment of the technology platform for the long term is important to sustain the solutions.

Ownership of the technology is equally important in mobile learning (Corlett *et al.*, 2005); (Traxler, 2010). But, mobile learning approach cantered on student devices is challenging as well. "From a methodological perspective it is easier with a homogeneous technology platform and also easier from a staffing and infrastructure perspective but such solutions are unsustainable because they are predicated on finance in order to provide devices"(Traxler, 2010). From a developer's perspective, creating solutions for a locked-down device restricts creative and innovative development as well (Moore *et al.*, 2009).

The selection of the open-source mobile platforms (Nanonote and Wikireader) for this study was based on the requirement of this module which is to enhance students' understanding of the limitations and constraints when writing software for embedded devices. We needed mobile devices that were comparatively cheaper (sub US$100), freely customizable and portable that students could use anytime anywhere without incurring extra cost. The use of such cost-effective open-source platforms support creativity and provide freedom and unlimited choices for students. We believe that the chosen platform may allow us to move our pilot to the mainstream of educational provision and finding secure and sustainable funding and support (Traxler and Leach, 2006).

Preparation of Devices

The university has a Windows based network and there is no dedicated lab for Mobile and Networking students. However, in one of our lab, we setup each computer with a dual boot Ubuntu and Windows operating systems. In the existing system, university does not allow students to install necessary open-source software. Therefore, by introducing these mobile devices, we were hoping to relax such constrains and provide total freedom for students to practice programming in the university and also outside the institutional contexts.

The Nanonote devices were customised to support the necessary software to provide hands on experience of packing data and communicating it across different kinds of hardware. Setting up devices was a non-trivial task, but worked well after careful preparation. Due to the specialised nature of the module, students were also free to customise their devices, such as changing the default distribution and adding multimedia content. The device related and available software are well documented and freely available online.

The Nanonotes were configured with lightweight JlimeMuffinman Linux distribution which has been built using OpenEmbedded with Jlime look and feel. It included already configured several useful stripped-down versions of applications to supplement it and also a complete software repository. The current image provided a X Environment, Matchbox window and desktop manager, and several useful applications such as video player, music player, image viewer, text editor, terminal, PDF viewer, dictionary and games. The devices were then loaded with necessary PDF manuals.

The Wikireader devices were also customised to provide access to necessary resources. Initially, the plan was to setup a course wiki based on the university's virtual learning environment (VLE), so that the lecturer can create and edit articles, but anyone can read those articles and leave comments. But, to customise the Wikireaders, we needed to upload the content from the course wiki to the device, which required importing an XML dump to be compiled and copied to micro-SD cards. Due to lack of flexibility of the existing VLE, we had to setup a new Wiki site using an open-source Mediawiki of which we had a full control. The site was setup in such a way that only the lecturer could edit the pages. Then, Wikireaders were customised to provide an offline access to Packedobjects manual and also imported freely available English Wikibooks, Wikiquotes, Wikidictionary and a full Wikipedia.

LEARNER ASPECT (L)

Our Masters programmes attract overseas students, mainly from India. These students can have difficulties adapting to a UK university learning environment. Some of them also have limited access to ICT resources outside the university. Previously, we have also experienced students' inability to make a significant improvement in MAD module due to lack of programming skills and unfortunately many dropouts or change their course pathway where programming is not compulsory. While those who decide to do this module, many struggle as they often fail to recognize their own deficiencies.

In this pilot study, all the students were male and were below 25, except for one student with age range 26 – 35. All the twelve students had regular access to desktop computer with Internet at home or university lab and library and good experience of using them for personal, work and study purposes. They also owned variety of mid-range to high-end mobile phones. 83% of students had post-paid (contract) phone but only 33% students had data usage plan. Most of the students were concerned about the cost of using mobile internet. Some of them did not need to use mobile phone for browsing as desktop use was sufficient for them and when available, some students preferred desktop computer to mobile device for accessing the internet.

Previously, none of the students had seen or used these relatively new Nanonote and Wikireader devices. However, they were enthusiastic and showed interest in participating in this pilot study as they thought it would be useful to have an access to resources offline to support their study and also use for hands-on experience.

DEVICE USABILITY (dl)

While Wikireader is a dedicated offline text reading device, Nanonote is a general purpose Linux computer. This study is therefore not a comparison between these two different devices but instead their evaluation for the purpose of mobile learning.

Wikireader

All the students said they used the Wikireader a few days a week to read and used it at home and while travelling as well. Out of 6, 5 of the students found it very useful for reading, while only 1 student found it somewhat useful. Most of the students found Wikireader easy to use. The most important advantage that students highlighted was the readily available content without using Internet in the portable, handheld and easy to use Wikireader device that supported uninterrupted reading at home or at work and also while travelling. As one of the student described the benefits: "*easy learning process, can be used anytime, anywhere, easy to carry in the pocket, no need of internet, low cost and very fast access to useful information*".

However, some of the concerns were the difficulty to search long phrases, sometimes not getting results as expected, having to go back to ‘home’ while navigating through the text, poor screen resolution, not knowing how to adjust backlight and not being able to read on nights. More than half of the students found onscreen keyboard neither easy nor difficult to use, while 2 students found somewhat difficult to type as they found touch screen unsmooth.

All the students found the ‘Search’ and the ‘History’ functions very useful and easy to use. But only 2 students found the ‘Random’ function useful, while 1 student found somewhat useful and 2 students never used this feature. Only 2 students used the device for reading other than the Packedobjects software manual. They found dictionary and quotes particularly useful.

While the low-spec Wikireader was easier to use and read texts, students did not attempt to update the device with their own content as there is no automatic synchronisation or straight forward updating mechanism. For newer content, the device software needs to be recompiled with XML dump and copied to the MicroSD card. A further research is needed to develop a tool to facilitate this process so that a common user can also customise the device easily. Therefore, we encouraged students to explore the open-source platform to appreciate its benefits to full potential.

Nanonote

In our study, 4 of the students used the device a few days of week, while the other 2 students used only once a week. They used the device mostly at home and 2 students used while travelling as well.

Half of the students said reading on Nanonote was rather easy and the other students found somewhat difficult. They found reading PDF on the Nanonote was difficult due to small (3” size) screen and the difficulty to use the compact 59-key keyboard which had a considerable impact on the ease with which students could navigate through text. Even though students found thumb typing on the Keyboard convenient, they felt it was slow due to its layout and the small keyboard buttons and therefore said it needs more practice.

Even though some of the students found the Nanonote useful for reading PDF documents, they felt a steep learning curve to use the device and the software. In general, using the device required remembering functions of certain keys or combination keys. Reading PDF documents required extensive scrolling both horizontally and vertically and also needed to remember different keys configured to start and close the application, zoom in and out while reading the document and to go to different pages.

However, beyond reading documents, one of the students also found Nanonote very useful for listening mp3 audio and watching videos while travelling. A student compressed the video using freely available software and copied to the device. While all the students appreciated the use of Nanonote to understand and learn the programming for embedded devices, only a couple of students attempted to flash the device with the minimal OpenWrt image containing GNU Guile built by the tutor and used for testing the command-line software they developed as part of the second assignment. As they had an unlimited access and control of this device, students were able to install and remove software, customise as necessary which they could not do in the lab computer. However, it is likely that prior instruction in their use will be needed as most of the students felt customising Nanonote will be somewhat tedious for the novice Linux users.

Analysis of Activity Logs

Regardless of lack of Wireless connectivity, all the students said that they used Wikireader both at home and while travelling, but Nanonotes were used mostly at home. From the activity logs, we found 60% of the usage of the devices was at Home and 40% was while travelling. They used both devices from few minutes to half an hour and up to maximum one hour. While using Wikireaders, all the students said that they sometime made notes on paper but only two users made notes on the paper while using the Nanonote.

The analysis of log shows, results of the 70% of the activities on Nanonote devices were useful, 10% of the results were somewhat useful and 20% of the results were not useful. On Wikireader device, students found the results of the 77% of the activities useful, 9% of the results somewhat useful and only 14% of the results were not useful.

From the log we were also able to quantify the number of problems students encountered while using these devices and the result supported the views students expressed in the post-test questionnaire. It shows that students encountered 60% of the usability problems and 40% were the technical problems while using the Nanonote devices. They faced technical problems such as difficulty in setting up DNS forwarding, difficulty in installing the tools needed on the desktop, which were solved with tutor’s support in the lab. But it shows there were significant usability related issues especially the difficulties of using the software, the small keyboard and navigational issues while reading the content.

Wikireader users noted 28% of the technical problems related to typing especially long phrases on the touch-screen and 72% of usability issues were related to adjusting backlight, sleep mode and navigating using back button. Some of the activities were also related to searching for information unrelated to the course and students found unsatisfactory or limited results.

Portability: Even though these devices are small enough to fit into pocket and easy to keep it safe and secure physically, one of the students lost the Nanonote in the last week of the pilot study.

Assignment Results

We noticed the differences in the average results for the two assignments (A1 and A2) comparatively (see Figure 2). In the first assignment, students achieved average 56.66% and for the second assignment they achieved average 61.83%. Overall, the average mark for the mobile application development module was 61.83%. However, three students actually achieved less mark in the second assignment than in the first assignment and in aggregate, two of the students could not achieve minimum 50% required to pass the module and therefore needed to re-sit.

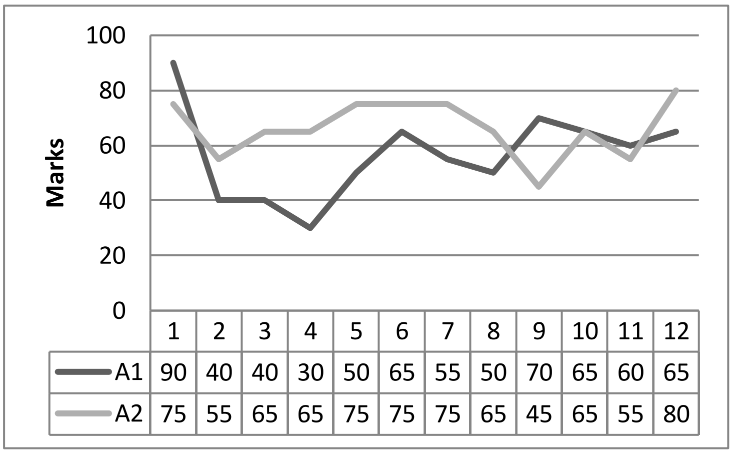

Figure 2. The comparison of marks for the two assignments (A1 and A2).

LIMITATIONS

The aim of this study was not to identify and measure the impact on learning embedded programming and also not meant for generalising our findings to a larger population due to small number of students' participation in a short period of the study. Therefore, the findings of this study should be used with caution to inform other programming education related studies. As this study mainly focused on the device usage, the results provide indications on students' perceptions towards the effectiveness of open-source platforms for student support and the findings could also be useful to support the adoption of offline mobile learning model to provide an access to resources and support learning.

CONCLUSION

In this paper, we reported an exploratory evaluation study of relatively low-cost / low-spec research-oriented open-source mobile devices to teach embedded programming. It has helped us to identify the benefits and limitations of the Wikireader and Nanonote devices by exploring how students perceived and used these devices, and how well they believed these devices supported their learning activities. This has demonstrated the feasibility of a hands-on approach that can be used to improve the further use of such devices in teaching programming.

In this study, the Nanonotes and Wikireaders were perceived by the students to be an effective tool in support and learn embedded programming. An access to these mobile devices provided opportunities for students to use the devices throughout the term for learning. Students found Nanonote device useful for practicing hands-on programming for embedded device than general reading purposes. While Wikireader device can also be customised, students found it more suitable for uninterrupted anytime anywhere offline reading. Students were not concerned about the lack of wireless Internet access, as the devices were provided with required resources for the specific subject they were studying. Therefore, this study recommends further explorations of the potential of affordable open-source platforms to develop an effective and sustainable offline mobile learning solution to provide ready access to resources and supporting teaching and learning embedded programming.

This study also highlighted that to take a full advantage of devices as such and to progress quickly, students must be supported in the early stages and their usefulness must be visible to them at the beginning. As the students are usually under pressure to complete assignments and prepare exams for different modules, they are unlikely to invest valuable time learning the devices so that they could possibly use for supporting the study. It is crucial to identify and provide the useful resources that students really need and align the use of the devices with the requirements of the module to enhance the learning experience by exploiting the potential added value these devices could bring.

Similar to Kenny et al (Kenny *et al.*, 2009b) findings, guided by Koole's FRAME model (Koole, 2009) of m-learning, we also found "access to and usability of mobile learning devices is critical to supporting the context of learning and learning interactions". Therefore, even though open-source platforms provide the greater flexibility and freedom that can be leveraged to shape the design of future cost-effective and sustainable mobile learning solutions that students really need, it is also important to provide a satisfactory user experience at the same level or else effectiveness of using such devices cannot be realised and the solution is more likely to fail.

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Appendix R (Conference Paper 4): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2011). "The English Language Teaching and Learning Challenges in Public Schools of Nepal: Teacher's Diary Study", IFIP WG 9.4 Conference, Kathmandu.

THE ENGLISH LANGUAGE TEACHING AND LEARNING CHALLENGES IN PUBLIC SCHOOLS OF NEPAL: TEACHER'S DIARY STUDY

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Abstract: In the context of developing regions, despite the decreasing cost of ICT infrastructure, supporting education with conventional e-learning technologies using standard paradigms is often regarded as shortsighted approach. Thus, researchers are increasing the focus on relatively cheaper and sustainable mobile technologies to support education. However, before implementing the technology enhanced learning solution, it is crucial to take account of the existing teaching and learning practices and design solution based on the distinct understandings of local context to fully incorporate technology in the existing educational process. This paper describes an exploratory study, carried out to identify the challenges of teaching and learning English in the government schools that use traditional teaching practices in Nepal. A teacher's diary study method was used to understand the background and the paper highlights existing pedagogical, technological, social and cultural issues – that might be useful for guiding the technological intervention in public schools where one of the current and the urgent requirements is to provide an access to digital contents.

Keywords: mobile learning, ICT4E, ICT4D, open-source platform, Technology Enhanced Learning, Nepal.

1. BACKGROUND

Nepal is a mountainous country where most of the countryside is remote and about 42% of the population lives below the national poverty line. According to the United Nations Development Program, poverty in Nepal has increased over the past three decades, especially in rural areas (UNDP, 2010). It has an estimated population of 23.4 million and at least 15 major racial groups(Vaidya and Shrestha, 2010). A large proportion of the rural population of Nepal is illiterate, as the literacy is around 55% in which, Nepali (national language) is 82% and English is approximately 18%(ENRD, 2009). Approximately half of the population in Nepal lacks the basic skills of functional literacy and numeracy (MOE, 2009).

There are Nepali non-profit organizations such as Open Learning Exchange (OLE) and Nepal Wireless Networking Project (NWNP), working towards improving quality and access in Nepal's public education system and currently NWNP is also in the testing phase of using the network for online-based learning (Thapa and Sein, 2010). Shrestha (2008) reviewed the state of the overall English Language Teaching (ELT) in Nepal and highlighted the unsatisfactory ELT situation in the country due to ineffective teacher education, the medium of instruction, language policies, university entrance examinations and a lack of resources. But we are not aware of the studies which explored the challenges to introduce technology in education and the use of mobile technologies to enhance teaching and learning in public schools of Nepal.

The objectives of our research are: i) to identify the current challenges in public schools that lack access to Information Communication Technology, ii) understand how ICT is helping to address such concerns in schools that have privilege to use the technology in education, and iii) explore the opportunities to supplement the existing teaching and learning practices by providing a much needed access to digital resources using low-cost open-source mobile platform (Shrestha *et al.*, 2011b). In this paper, we present the findings from the initial study that we conducted in eight public schools located within an urban area of Chitwan district using a pre-questionnaire and 2 weeks long English teachers' diary.

The organization of this paper is as follows: section 2 is a literature review and theoretical orientation; section 3 discusses the methodology and demographics; section 4highlights the challenges of delivering learning in government funded public schools of Nepal; and section 5 concludes the paper.

2. LITERATURE REVIEW

The exploration of the use of mobile technology to support language learning around the world is increasing which shows that the ICT intervention in language teaching and learning is facilitating transition from teacher-centred approaches towards more student-centred ones, such as Communicative Language Teaching (Vihavainen *et al.*, 2010). There are a number of studies that focused on mobile learning in the context of developing regions like Africa, China and India which evaluated mobile learning in controlled classroom and unsupervised settings as well(Kumar *et al.*, 2010).

Previously, one of the applied research project in Sub-Saharan Africa showed the improvement to access and quality of an education by the use of mobile technologies (Leach *et al.*, 2006). One of the key policy implications raised by this study was the need to further investigate in a wider range of contexts and purposes of the potential of new mobile technologies. According to (Kukulska-Hulme, 2009), “Designing mobile learning solutions also need a clear understanding of what is best learnt in the classroom, what should be learnt outside, and the ways to achieve balance between these settings”.

Even though, serious education challenges cannot be solved by simply introducing computer and internet technologies in low-income schools (Warschauer *et al.*, 2004), there are evidences of the use of ICT in education within developing countries that demonstrated its potential to have a positive impact when an appropriate technology was combined with quality curriculum-based content (Sahni *et al.*, 2008; Hollow and Masperi, 2009; Hutchful *et al.*, 2010; Thapa and Sæbø, 2011);. In a recent study of the role of NWNP and use of ICT in the context of an underdeveloped remote mountainous region of Nepal, it has shown how ICT is helping to develop and extend the social capital, which assists people in developing and improving their education, healthcare, communication, and generating economic activities (Thapa and Sein, 2010).

Therefore, it is crucial for technology research to identify the best-fit solutions for developing regions (Brewer *et al.*, 2005) that integrates with the social and cultural practices of the locality to make sure it is a sustainable solution and for long-term use and benefits (Evans *et al.*, 2008). A detailed discussion of wide range of technical, environmental, and cultural challenges in general (mainly in the context of India, Ghana and Cambodia)provided some guidelines for implementing different ICT related solutions in developing regions (Brewer *et al.*, 2006). However, the challenges of introducing ICT for education in countries like Nepal stretch beyond the economical, infrastructural and other technical requirements. Thus, there is also a need for an understanding of existing teaching and learning practices in the current social, cultural and political context of Nepal, and therefore our study has a socio-cultural theoretical orientation.

3. METHODOLOGY

The study was conducted in Chitwan District of Nepal and the organization of this study and the data collection was completed in two and a half months starting early August 2010. Eight government funded schools within the district were randomly chosen to participate in our study. From those schools, we selected 16 teachers (2 from each school) responsible for teaching English for year 9 and 10. All the schools are located in and outskirt of Narayangarh, which is a small town situated 140 km South/west of the capital of Nepal, Kathmandu. Our decision to conduct the study in this particular area was due to time constraint and limited financial resources. There is also limitation on the generalization that could be made on the findings of this study as the schools are located in a relatively developed part of the country.

We collected qualitative data without researchers needing to be physically present at the site to supervise the study during the study period, which minimized the risk of influencing teachers' behaviour. The study was, supported by a native social worker who is also a respected retired teacher. He also has an excellent local knowledge and rapport with the schools and the community, which immensely helped us to establish the relation with schools and our credibility among the teachers.

Initially, we contacted head teachers of all the schools and were given permission to speak to teachers. We obtained the written informed consents from the teachers who agreed to participate in this study and administrated the pre-questionnaires and analysed the demographics. Then, teachers were provided a diary and a pen to enable them to self-report which also encouraged a sense of 'ownership' of the diaries, as both a process and a product (Hall, 2008). According to David McLachlan (Jeffrey, 2007), "Teacher diaries also generate a self-awareness which is beneficial for the personal-professional development of teachers, as they involve inwardly reflective procedure of writing about what happened in the classroom, and then analysing the entries for deeper insights".

We decided to conduct a paper-pen based diary study, as approaches such as combining data logging with e-diary in field trials (Liu *et al.*, 2010) are more suitable for the browser/server based architecture and also due to the cost of implementing such an approach and the limited access to Internet technologies. Indeed, diary study can suffer from the drawback of potentially missing data, because participants forget to record entries or are selective in reporting (Bolger and Davis, 2003).Teachers are very busy and writing diaries require dedication as well (Jeffrey, 2007). It is also possible that participants may find it difficult to write unprompted (Hall, 2008). Therefore, to minimize such issues, we provided a list of 25 open questions that teachers used as guidance which helped to collect their thoughts and write down teaching and learning related experience. The questions helped teachers to articulate their perceptions and where available, our interpretations of their diaries are backed up by the findings from previous researches.

The questions focused on understanding the value of English language in Nepal's context, how English is taught in public schools, teaching techniques used, the social and cultural norms that are peculiar to each school, issues related to infrastructure, availability of resources and access to ICT, government and school's support in teaching English, the preconceptions about the role of ICT, mobile device in particular and expectations of how useful it would be in the context of learning. All the teachers added an entry to their diary in English language either in the school or at home. The choice of English medium instead of native Nepali language for writing diary may have affected quality and quantity of data collected in our study.

All the diaries were transcribed, summarized, coded and categorized manually. From this interpretive study, we present the challenges of achieving the objectives proposed by the English curriculum of government funded public schools of Nepal and highlight why teaching and learning English is not effective in public schools.

3.1 Demographics

Out of sixteen, only two teachers were female. The age of five teachers was below 35 and the age range of rest varied from 36 to 65. Ten of the teachers have access to desktop computer at home, three have access at school and the other three teachers have no access to desktop computers and no experience of using them as well. Those who have access, have a low to average desktop using experience and they use the computer for personal use. Only five teachers said that they use desktop computer almost every day. Eleven of those teachers also have access to internet but most of them go online once a week or less than once a week for personal use. Interestingly, all the teachers have access to mobile phones and have an average to a lot of experience of using the phone. Ten out of sixteen teachers own low to mid-range Nokia phone (models range: 1600, 6030, 6085, 6120c), and the rest have a Nokia 5800 music express, Samsung (e1160 and e2130), Benq and Motorola (model not mentioned), and also a Chinese G'Five V80 mobile phones.

Out of sixteen, only two teachers are on contract (post-paid) plan and the rest are on 'pay as you go' (prepaid) plan. Only three teachers have limited mobile internet using experience and all the teachers use their mobile phones mostly for making calls and text messaging. Most of the teachers are concerned about the cost of using mobile internet. Some of them do not need to use mobile phone for browsing as desktop use is sufficient for them and when available, some teachers prefer desktop computer to mobile device for accessing the internet. In the below section, the findings from the diary study is discussed in detail.

4. THE CHALLENGES

Nepal has both public and private schools. In the existing Education Act and the relevant Regulations, the school supported by government has been recognized as 'community school', while the privately owned school is called the 'institutional school' (MOE, 2008). Generally, private schools are English medium, and many also introduce computers in the curricula. Even in public schools, English is taught as one of the compulsory subjects. In higher education, the importance of English is even greater as it is the preferred language to access the scientific literature and the economic opportunity in employment abroad (Hall *et al.,* 2009).

According to (Graddol, 2006), "the recent trends in the use of English worldwide and its changing relationships with other languages is due to the economic globalization which encourages the spread of English but the spread of English is also encouraging globalization". The motivation to teach and learn English is clearly driven by the understanding of its value in a much broader context. The importance of English language is such that teachers refer it as an international (global) language, a popular language, a practical language, a must-have knowledge and a passport to travel all over the world. One of the teachers highlighted the importance of English language:

English is the language of a modern technology. It is important to teach English because most of the valuable books are written in English and medicines, newspapers, computers knowledge are in English language. English is for getting good job in the context of our country (Nepal). *It is for higher education, and for studying abroad.*

Thus, even though providing localized resources will have wider use and impact in Nepal's education, we believe that English based resources will also be useful for students and teachers. But, to provide access to digital resources and to introduce ICT for developing education, there are significant challenges that need to be considered.

4.1 Teaching Techniques in Public School

English curriculum and textbooks are designed and developed to improve communicative skills; fluency and accuracy in communication are therefore desired goals. But teaching English is not succeeding in public schools due to use of grammar-translation method and chorus drills in their lessons and the limited use of pair and group activities, which are central to communicative language teaching (CLT) in the West (Shrestha, 2008). Teachers find it difficult to apply modern techniques of teaching as one of the teachers described the teaching in public schools as an act of depositing under the current situation, a phenomenon similar to the Banking view of education eloquently described by Freire (1996):

Worse yet, it turns them(students) *into containers into 'receptacles' to be 'filled' by the teacher which they patiently receive, memorize and repeat. The more completely he* (teacher) *fills the receptacles, the better a teacher he is. The more meekly the receptacles permit themselves to be filled,* the *better students they are.*

Most of the teachers stated the problem is also in use of a translation method as preferred by students and teachers. Previously, Nepalese students were described as passive learners relying on their teacher to provide the material to be learned(Watkins and Regmi, 1990). As computing is almost non-existent in the great majority of educational institutions (Goodman *et al.*, 2000), even today, education is still traditionally text-book oriented and therefore dependent on teachers as only reliable resource. Students find very difficult to learn English and they rarely use English language even within the classroom. Therefore, every item is translated into the vernacular language. Students' inability to communicate is mainly due to lack of interactive/communicative activities in English-language lessons (Shrestha, 2008). A teacher highlighted the use of such method and its consequences in learning:

It is because they(students) *study all other subjects in Nepali medium and English is the only subject they learn in different language. Therefore, most of the schools' English subject is taught by translating in native language, which at the beginning phase sounds suitable, but in the long run it has adverse effect upon the students' ability to understand English and speak fluently.*

Another teacher said:

Using such method, teaching and learning English language becomes tough and gradually students pay less attention to learn the language. Eventually, the motive of teaching and learning English is considered as passing the examination rather than making the students communicate in real life situations and their weakness even promote them to cheat in the exams.

4.2 The English Learning Environment

Students in public schools have rarely or no interactions with English speakers outside school. But the schools also lack English learning environment within the school and rarely use English language even in the classroom. Therefore, a teacher said, "English is difficult for not only the students but for the teacher as well." Some of the teachers provide private tuitions for students from their own school or from outside as the students seek extra classes to pass the exam with good marks. A study of a Private tutoring in English (PT-E) for secondary school students in Bangladesh showed that the students saw private tutoring as imperative for successful learning achievement (Hamid *et al.*, 2009).

Based on the observation of one of the teachers, the root cause of weakness in English starts from primary level and the concerns should be focused on this level. It has been highlighted that in some schools the students from primary classes are graded every year in upper classes though they almost failed in English. As a result, when they reach secondary level, the English teachers face bigger challenge of teaching the language. (Shrestha, 2008) found the lack of training of primary schoolteachers, which means there may be even fewer primary-school English teachers with appropriate skills and knowledge to teach English to young children. According to MOE (2009b), "On one hand, all school teachers are not trained and on the other, trained teachers do not get enough teaching material to make teaching and learning process effective".

Teachers also pointed out that the allocated time for teaching English is not enough, as only 5 periods are provided in a week to teach English. However, under the current circumstances, all the teachers in these schools teach average 25 hours a week. A teacher's view on this matter:

Teachers in government schools are overworked, underpaid and not as respected as they should be. There is no effective means of evaluation as well. Provided that they (teachers) are not going to be evaluated, negligence does occur.

4.3 The Social Inequality

The teachers highlighted that the different cultural background and economic status in the community is clearly affecting the teaching and learning practices. In Nepal, generally, those who can afford, send their children to the private English Boarding Schools, as the quality of education is believed to be better than the public schools which is also reflected in the annual school leaving certificate (SLC) exam results (Watkins et al., 1991: 37-38 in(Shrestha, 2008). Circumstances are such that:

Due to the guardian's illiteracy, lack of knowledge and poor economic condition, they do not know the value of education and unable to provide good environment and want their children to stay at home and support in household work. As they have to work and support their parents in the morning and evening, students from these very poor families don't attend class regularly.

A previous study also showed the reasons for out of school children are "the poor family condition, lack of awareness about importance of education among the parents, lack of child friendly school environment and socio-cultural beliefs and rituals" (MOE, 2009b).

A teacher described the private and public schools as two opposite poles. Private schools are profit-oriented, have an expensive fee structure and books that the poor cannot afford. An average annual cost per student is US$ 65 in public schools whereas it is US$ 205 in the private schools (MOE, 2008). According to Asian Development Bank, "Nepal remains one of the poorest countries in the world, with per capita income of $447 per annum, wide income disparities, and poor access by a large section of the population to basic social services" (ADB, 2009). Owing to this, the majority of students in a government school are from underprivileged/marginalized group, backwards and schedule casts. The serious consequence is that it deepens the social inequality that already exists even further by clearly dividing the society between rich and poor in a Nepalese ethnically diverse and complex society.

4.4 Lack of Resources

In public schools, the lack of teaching materials is also a major problem. Poor students cannot afford to buy reference materials and practice books, as highlighted by a teacher:

Almost all the government schools say that they don't have money to buy books, magazines and newspapers. As a result, pupils are deprived from reading extra materials. They have to rely on the textbook only. For listening activity, they don't have cassette player. If they have, there is no facility of electricity. There are a lot of attractive books available in bookshops, but students cannot afford to buy them, because most of the students in government school have poor background family.

In Nepal, there is also a shortage of relevant materials in local languages relevant to their needs. Including the technical challenges of developing suitable services to provide access to digital resources, one of the harder challenges of delivering localized learning materials in Nepal is the English language itself. Despite low levels of familiarity with English language, as highlighted before, its importance and socioeconomic value is very high (Hall *et al.*, 2009). (Goodman *et al.*, 2000) also states that "unlike other one-country languages, Nepali suffers from not being universally spoken even in its home country". A(Shrestha, 2008) "Even though, the English Language Teaching (ELT) situation in Nepal is far from satisfactory, it has affected the society as a whole, particularly the English-vernacular (Nepali) divide in the country".

The National Curriculum Framework (NCF), 2006 has emphasised on the need for education in mother tongue, and incorporation of local contents in school curricula. A recent study (MOE, 2010) carried out by ministry of education reviewed the existing status of local contents, and mother tongue education and highlighted the major challenge is to change the English language oriented mind-set into the mother tongue. The study showed the significant increase in the demand of English education at the community level. As the study showed, the two reason that the schools are using optional English as a local curriculum instead of promoting the local knowledge are, "First, it helped to fulfil the parental expectation; Second, it has made easy to the schools and the teachers to implement the local curricula as they do not need to take further initiative of developing the local curricula and the curricular materials".

4.5 The Infrastructure

Nepal faces the biggest challenge of establishing the proper information infrastructure as the topography makes it extremely difficult to develop the much needed telecommunications infrastructure.

MOE (2009b) states that "The government's policy is to build a school around half an hour walk from the child's home" and all the eight schools involved in this study are conveniently located in or the outskirt of Narayangarh town. But, teachers are concerned with the lack of physical facilities, especially the over-crowded classrooms and the imbalanced teacher-student ratio across schools. In the 8 schools we studied, the average class size was 56 students per class.

Only income source of a public school is the grant/subsidy provided by the government, which means many public schools are unable to spend for any other activities (MOE, 2008). The lack of well facilitated rooms and proper teaching aids especially to use in the classroom are the major problems faced by teachers and therefore they find it hard to use the informal teaching methods. Electricity is available in these schools but it is very unreliable. While Nepal electricity authority is planning for further power cuts and hike the electricity tariff by 30 percent (nepalnews.com, 2010b),the use of multimedia equipment such as cassette player is not common in the classrooms. A teacher expressed his frustration:

Load-shedding is sometimes more than 12 hours. So it has adverse effects upon teaching and learning activities. It creates problems to run our already limited computer classes and other ICT programs.

4.6 The political Instability

It has been more than 4 years since a 10-year civil war between the state and the Maoist rebels ended in Nepal. However, the country is still suffering due to a political instability and weak governance, and there is no certainty when this transition phase will end. Because of the constant feud and disagreements between Nepal’s biggest parties, there is a political deadlock and Nepal still has an interim-government and a constitution has not been written yet. Even though government may show willingness towards development, the impact of the current political situation is felt in every sector and hampering the growth.

Considering what is currently being done from the government level to revitalize the educational practices, teachers stated that there is a lack of clear policy about education and believe that Nepal is not on the track to achieve the goals of Education For All (EFA) by 2015 (MOE, 2009). Schools lack investments from government level in novel educational techniques and support teaching. Teachers also raised the issue of politics and mismanagement of resources within the school:

We are facing the situation of anarchy. Everywhere in the government schools, there is a direct and indirect interference of political parties. The involvement of teachers under certain political umbrella is one major cause for loosing standard of government schools. The schools open for only 150 days, while it meant to open for at least 220 days according to the government calendar.

4.7 Access and Role of ICT

Indeed, GPRS/3G networks and handsets are becoming cheaper. However, regardless of the fastest growth of mobile phones in the poorest regions (Heeks, 2008); common use of expensive smart phones is not yet possible in public schools of Nepal. Most of the teachers that took part in this study have said that they and the students do not have basic knowledge of using ICT, as in most of these schools, computer lessons are not part of the curriculum mainly due to the lack of funding support. A teacher stated:

We have just seen and heard about ICT but we don't have basic knowledge of using ICT. Only a few teachers and hardly a small number of students have access to ICT. Some schools may be equipped with ICT while the most schools have no access to it.

A couple of schools that have computers are being used for accountancy or some other official purpose. Those schools with a limited computer access do not use it for teaching and learning English as one of the teacher mentioned:

Our school has run computer as an extra subject since last year only for the students of lower secondary level. Only computer teachers are involved in this subject.

In these schools, the affordability of computing remains a primary barrier(Ho. *et al.*, 2009). Also, (Hutchful *et al.*, 2010) highlighted the teachers' low computer proficiency may affect their ability to create digital content needed for teaching. Therefore, even though the innovative but simple solutions such as Multiple Mice project (Pal *et al.*, 2009) can provide financial and learning benefits, it is important to design a product that supports simplified process for teachers to engage in computer-mediated learning.

In this study, most of the teachers stated that the introduction of technology into classroom will help both teaching and learning process. As one teacher expressed his positive perception:

The traditional way of teaching is out date. Chalk and duster which has been only tools of teacher need to change. Computer, projector, cassette player are supposed to be urgent requirements for the school which are out of our access. I think ICT will facilities us to teach and learn better English by making our task motivating and effective. It may create a rich environment for language learning. It offers great potential for student interaction and practice with authentic communicative language functions.

In higher education of Nepal, English as a medium of instruction is widely used than at school (Shrestha, 2008). Referring it as a critical situation, another teacher stated why it is so important to improve English language teaching in public schools:

Our previous records show that the students from government school, as they are weak in English, unable to get admission in technical institute. And, to avoid this, our total attention should be paid on course book design, resources and the techniques used.

4.8 Mobile Platform

Relatively cheaper mobile technology, compared to desktop computers and laptops, has more realistic adoption possibilities and help both teaching and learning process. A teacher said:

These days it seems mobile phones are used everywhere by everyone. They are increasingly powerful devices. Most importantly phones are social tools that facilitate authentic and relevant communication and collaboration among learners. By using mobile device, I think we can motivate students and encourage them to participate in class activities.

Mobile learning researchers around the world are focusing on integrating smart mobile devices (such as iPhone and iPod Touch) into educational institutes' curriculum and support formal and informal learning. English in Action is one of such current project in the context of Bangladesh (for more detail, see (Power and Shrestha, 2010). But the cost of the device is also one important factor (Chhanabhai and Holt, 2009) and only inexpensive platforms can facilitate rapid application development (Ledlie *et al.*, 2009). It is important to consider cost-effective alternative platforms to high end mobile devices and also, from a developer perspective, developing solutions for a locked down device restricts creative and innovative development (Moore *et al.*, 2009).

Teachers stated that introducing mobile technology in schools will require financial support as the students are from poor background and for its successful adoption it is important to be a part of existing curriculum. Therefore, to deliver and support learning as a key aspect of a sustainable mobile learning solution, the importance of considering an appropriate target mobile platform before proposing, developing and piloting such solution is recommended (Shrestha *et al.*, 2010c). Including the cost for the device, it is also important to consider the cost that users may have to pay for using the mobile services.

5. FUTURE WORK

This study shows a very low penetration of computer and mobile technologies and Internet connectivity is mostly unavailable in public schools of urban Nepal. Nepal is a mountainous country where 86 per cent of population lives in rural areas(Vaidya and Shrestha, 2010), and the education in rural public schools is even more challenging. Therefore, even though ICT based services provide opportunities to improve teaching and learning, poor information infrastructure, lack of resources means the necessity to develop an affordable mobile learning solution that does not completely depend on the availability of wireless network, internet connectivity and smart devices. The challenge is also to support the traditional teaching and learning practices considering the existing socio-technical issues.

With the overall deeper understanding of ways of teaching and learning, needs and concerns in government schools of Nepal, we will conduct a similar study in private schools for a comparison as the quality of education is believed to be better than the public schools. A further study will be conducted to identify the type of resources that will be useful for teaching by understanding how teachers go about preparing lessons; what type of information they use to prepare lessons; where do they get the information from; how do they share material with fellow teachers and if there was a device to help prepare lessons what content would they like to have?

Similarly, another study will be conducted in the schools supported by OLE Nepal in Makwanpur and Kapilvastu districts to investigate how the use of ICT in teaching and learning may be helping to solve some of the concerns highlighted in this paper. Then, based on the findings from these studies, we aim to explore the use of low-cost open-source mobile devices to deliver customized contents in public schools to support English language teaching and learning. We believe open-source hardware and software does not only lower cost in enabling Information and Communication Technologies in developing countries, but sustainably may increase access to much needed knowledge and learning resources that are readily available and freely accessible. This will also help focus on evaluating the usefulness of the proposed solution for supporting teaching and learning. The evaluation will use mixed methods research methodology and adopt an approach recommended by Sharples (Sharples, 2009), which is to address usability (will it work?), effectiveness (is it enhancing learning?) and satisfaction (is it liked?).Data analysis will be guided by the Framework for the Rational Analysis of Mobile Education (FRAME) model(Koole, 2009).

6. CONCLUSION

The idea of this paper is not to imply that the teaching and learning English in public schools is a failure. Instead, we have highlighted the existing concerns and why English language teaching may not be succeeding in public schools, regardless of how teachers are personally trying to incorporate changes at a teaching level to improve classroom learning experience and make learning student-centred.

This inquiry has helped us to gain deeper understanding of how the English teachers in public schools teach and deliver learning, how the courses are structured, and what could be their motivation to adopt Information Communication Technology to support teaching and learning. We hope that it will help to identify design implications concerning technology in the context of government schools of Nepal and this understanding of the background against which technological intervention can be designed. It has also helped us to identify teachers’ interest in the further research study.

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Appendix S (Conference Paper 5): Shrestha, S., Moore, J., Abdelnour-Nocera, J. (2011). Poster: "Open-source Platform: Exploring the Opportunities for Offline Mobile Learning", Mobile HCI 2011, Stockholm.

Open-source Platform: Exploring the Opportunities for Offline Mobile Learning

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Abstract

The mobile technology field is rapidly expanding and the focus on how it can be incorporated to support learning is also growing. However, the barriers to inclusion of information communication technologies in the public schools of Nepal are still significant and the widespread access to digital content remains a key obstacle. Nepal has a poor communication infrastructure and where available, telecommunication and electricity are poorly maintained or too costly to use. The aim of this exploratory research study is to highlight how an offline mobile learning solution may address some of the technical challenges to support one of the current and most urgent requirements to provide an access to digital content. It will investigate the deployment of previously unexplored low-spec sub US $100 open-source mobile devices to facilitate English language learning and address the knowledge requirements of teachers in government funded public schools of Nepal.

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Keywords

Copyleft Hardware, Offline Mobile Learning, Nanonote, Wikireader, Open-source Technology, Mobile Usability.

ACM Classification Keywords

K.3.2 [Computers and education]: Computer and Information Science Education – computer science education

General Terms

Design, Experimentation, Human Factors.

Introduction

There are ongoing efforts focused on developing the type of low-cost device targeted for developing countries. According to Toyama and Ali (Toyama and Ali, 2009), "the technologies developed for the first world have often been a poor fit in these area, due to issues of cost, infrastructure, physical environment, and social factors, and there is a need for technology research specially aimed at developing regions." It is therefore crucial for technology research to identify the best-fit solutions for developing regions (Brewer *et al.*, 2005) that integrate with the social and cultural practices of the locality to make sure it is a sustainable solution and for long-term use and benefits (Evans *et al.*, 2008).
Mobile technology is rapidly advancing and its increasing penetration in developing countries is also gaining a wider attention. But the penetration of highly subsidised smart devices in developing countries such as Nepal is comparatively very low and repurposing cheap existing mobile phones are not easy as well.
However, mobile technology has a potential to deliver education without dependence on an extensive communications infrastructure that suits the context of developing countries (Traxler and Kukulska-Hulme, 2005b). There are opportunities to explore the role of portable technologies to further expand the scope of e-learning environment thereby enhancing the learning process and also increasing students' learning interest and motivation.
As the cost of hardware reduces we are beginning to reach a point where it may become possible to replace a USB flash storage device in your pocket with a small computer. This style of ubiquitous computing provides some interesting learning opportunities but also poses significant technical challenges.

This study aims to introduce the Ben Nanonote (figure 1), an ultra-compact, lightweight pocket computer which has been developed following a copyleft approach and the Wikireader (figure 2) which is also an open-source handheld offline reading device. A copyleft open-source approach provides the opportunity for the community to directly influence the hardware roadmap of a device and thus may generate new and sustainable solutions within specific markets.

figure 1. Ben Nanonote- 3.0" color TFT display, 336 MHz processor & 2GB of flash memory; an ultra-small form factor Copyleft device by Qi Hardware http://sharism.cc/

figure 2. Wikireader – Handheld offline reading device by Openmoko. Runs up to 12 months on two AAA batteries.http://www.thewikireader.com/

The paper sets the scene by explaining the research problem, aim and objectives. Then, it describes the planned study in Nepal and the expected contribution. Finally, a conclusion is offered highlighting how the proposed approach may potentially meet the teachers' requirements.

Research Problem

The exploration of the use of mobile technology to support language learning around the world is increasing which shows that the ICT intervention in language teaching and learning is facilitating transition from teacher-centred approaches towards more student-centred ones, such as Communicative Language Teaching (Vihavainen et al., 2010). Even though, serious education challenges cannot be solved by simply introducing computer and internet technologies in low-income schools (Warschauer et al., 2004), there are evidences of the use of ICT in education within developing countries that demonstrated its potential to have a positive impact when an appropriate technology was combined with quality curriculum-based content (Sahni et al., 2008),(Hollow and Masperi, 2009),(Hutchful et al., 2010),(Thapa and Sæbø, 2011),(Thapa and Sein, 2010). But the penetration of computer, internet and mobile technologies are low and access to Internet is very limited in Nepal (Goodman et al., 2000) and the education is traditionally text-book and teacher oriented.

Therefore, to deliver and support learning as a key aspect of a sustainable mobile learning solution, it is vital to consider an appropriate mobile platform before proposing, developing and piloting a mobile solution. According to Pal et. al(Pal et al., 2009), "even though the quest for the low-cost computer has been one of the most significant pursuits of ICT4D, most projects have fared poorly in markets, despite the apparent enthusiasm for many such initiatives".

Mekuria (Mekuria, 2009) highlighted the need for next generation mobile technologies for a successful launch and operation of mobile learning solution and affordability and reliability of any innovative mobile web & broadband services. There are numerous initiatives to help bring services and new opportunities to the poor by exploring the potential of mobile technologies as a new range of hardware platforms to build innovative systems (Dearden et al., 2010). It is also crucial to develop an affordable mobile learning solution that does not completely depend on availability of wireless network, internet connectivity and smart devices.

Considering the challenges of introducing ICT for Education in Nepal, an offline mobile education may have broad application scope as it can minimize the complexities of providing learning by not having to deal with networking issues, malleability of design and content, simplicity and no steep learning curve (Shrestha et al., 2010a). The Wikireader and Nanonote are low-spec handheld devices that do not ship with any RF communication capabilities therefore its applications will fall under the category of an offline mobile learning.

In the context of Nepal, before trying to change or improve pedagogy of learning, the aim is to explore the applicability and benefits of supporting learning activities using an open-source technology by providing the much needed digital access to resources for English teachers in public schools of Nepal.

The objectives of this research are to i) address the challenges of delivering mobile learning in public schools of Nepal, ii) develop a simple technical solution (Donner et al., 2008), a solution that might be sustainable, scalable and work and iii) identify the implication of introducing a new technology in such a resources-constrained environment.

Future Work & Contributions

Considering the context and culture of Nepal, this research aims to develop a socio-technical– an offline mobile learning solution using a low-spec open source mobile technology. The study will be carried out in four stages.

I) Before implementing the technology enhanced learning solution, it is crucial to take account of the existing teaching and learning practices and design solution based on the distinct understandings of local context to fully incorporate technology in the existing educational process. Recently, an exploratory study was conducted using teachers' diary study method, which helped to understand the background and highlight the existing pedagogical, technological, social and cultural issues – that are useful for guiding the technological intervention in public schools of Nepal where one of the current and the urgent requirements is to provide an access to digital contents (Shrestha et al., 2011a). The qualitative study was conducted in eight public schools using a pre-questionnaire and 2 weeks long English teachers' diary.

II) A pilot study was conducted to explore the use of open-source platforms, customisation of graphical user interface, its usability and how it may be used for supporting teaching and learning (Shrestha et al., 2010c),(Shrestha et al., 2010b). Even though this exploratory study aimed at supporting teaching and learning programming in Higher Education, it mainly focused on better understanding the use offline mobile technologies, and on the device usability. The results provided indications on users' perceptions towards the effectiveness of open-source platforms for supporting teaching and learning and the findings could be useful to support the adoption of offline mobile learning model to provide an access to resources and support learning. The findings indicate these open-source devices have potential to facilitate offline reading and it can enhance motivation to learning.

III) With the overall deeper understanding of ways of teaching and learning, needs and concerns in public schools of Nepal, further studies are either underway or planned for the future. As private schools are generally believed to be better than public schools, an exploratory study was recently completed which involved 20

English teachers from 10 private schools within the same district. A further study will be conducted in 8 public schools from 4 different districts that use XO laptops and supported by Open Learning Exchange Nepal (http://www.olenepal.org/). The study identify the benefits and challenges of using ICT in poor schools and investigate how the use of ICT may be helping to solve some of the concerns identified from the earlier study. These studies will also help to identify the type of digital resources needed to support English learning in public schools of Nepal.

IV) Then, based on the findings from these studies, the use of low-spec and sub US $100 open-source Nanonote and Wikireader devices will be explored to deliver learning resources in five schools. The evaluation will adopt an approach recommended by Sharples (Sharples, 2009), which is to address usability (will it work?), effectiveness (is it enhancing learning?) and satisfaction (is it liked?). For the evaluation purpose, selection of the research methods for this study will be adapted from the earlier studies of adoption of mobile technology for learning by Corlett et al. (Corlett et al., 2005) and Waycott (Waycott, 2004). Due to exploratory nature of this research, data analysis will be an iterative and reflective process throughout the project and the data will be examined in relation to the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2009).

This study will also highlight the development challenges faced working with a sub US$100 device including usability issues and the lack of a standard graphical user interface. Overall this study will showcase alternative open hardware solutions to more restrictive proprietary solutions which are currently dominating the mobile landscape.

Conclusions

In developing countries, the penetration of mobile technology is relatively higher than the desktop computers and the idea of using mobile devices to learn and access educational tools and materials is also growing. However, regardless of rapid development of mobile tools and technologies, supporting learning in Nepal's public schools faces numerous challenges. Some of the key challenges of delivering mobile learning in Nepal are the lack of stable communication infrastructure and access to Mobile Internet, lack of access to learning resources in local and the English languages. Selection of affordable mobile devices suitable for delivering learning to suits such resource-constrained setting is therefore important for developing a sustainable mobile learning solution.

The main benefit of this study will be giving the users a one-stop access to learning materials at anytime and anywhere without requiring to go online using smart devices. It is however not possible to predict in advance how the teachers will use these unconnected devices for teaching and learning or even if they would adopt them at all. However, due to lack of resources, limited access to technology in the context of public schools in Nepal, it may be possible to see the clear benefit of use and deduce learning gains due to use of solutions based on such devices.

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