Integration of M-Learning and LMS: a Sustainability Approach

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Abstract— Mobile phones are widely used in both rich and poor countries, unlike what happens with other ICTs. The expansion of mobile telephony in poor countries presents an opportunity to fight against digital divide. In the latter countries, mobile phones are used to get information and services about agriculture, health, and education among other areas. Specifically in the area of education there are many who think that mobile phones are a useful tool to help achieve universal primary education, one of the Millennium Development Goals proposed by the United Nations. There are many educational experiences with mobile phones for development. But most of these experiences have serious limitations that affect their long-term sustainability. In this line, the current paper provides a set of guidelines to define more sustainable and long-term viable mobile-learning projects and presents its applications to a m-learning project: the Moodbile project.

M-learning; Learning Management Systems; Moodle; sustainability; Information and Communications Technologies for Development

1 INTRODUCTION

Information and Communications Technology (ICT) is regarded as a powerful tool for development [1-3]. Nevertheless, most ICTs face many problems in developing countries, in part due to the lack of adequate infrastructures. But despite those problems, to the date, there is one technology that is widely used and expanding in developing countries: mobile phones.

In the Information Society Report 2011 published by the *International Telecommunication Union* (ITU), the developing countries are experiencing an important increase on the use of mobile phones. The ITU states that: *"With 5.9 billion mobile-cellular subscriptions, global penetration reaches 87% at the end of 2011. In developing world mobile cellular penetration is 79%. The percentage of the population covered by a 2G mobile-cellular network is twice as high as the population covered by a 3G network.3G population coverage reached 45% in 2011"* [4].

The proliferation of mobile phones in developing countries is due to several factors. One of the most important ones is the relatively low cost of the mobile terminal. In many of the world countries, it is possible to find a mobile phone for a relatively low cost. This is due to the existence of a second hand market that allows people from developing countries to buy a mobile phone for a low price. These second hand market starts in the developed countries, where people tend to change their mobile phone regularly. These terminals that are no longer used in the developed countries, are sold in developing countries for a lower price [5].

Moreover, mobile phones are personal devices that serve many purposes for its owner: communications, photo and video camera or music. In developing countries they also have other uses, such as lanterns, since public illumination coverage is very low and many homes do not have electric power supply. For many people in developing countries, mobile phones are their only computing device and they are have become portable networked computers [5-6].

In developing countries, there is high demand of information related to health, agriculture and education. In the last years, SMS-based applications have covered this gap, creating a huge market for SMS-based applications [35]. SMS is now widely used in developing countries, because the access price is low and the infrastructure available supports widespread SMS usage [34]. The low price of SMS messages and the availability of adequate infrastructure are the main reasons why SMS-based applications are being used in developing countries rather than mobile Internet (which penetration rate is still very low in developing countries) [4].

Since mobile phones are usually the only computing device for people in developing countries and in these countries, there is also a high demand of information related to education, mobile phones can be very useful to support educational processes. The use of mobile devices for learning is called m-learning [7]. There are currently many m-learning projects in developing countries [32] [33]. But most of them are pilots or small-scale projects based on external funding that lack the ability to be maintained, updated and extended locally in the long term. In this context, this paper presents a series of guidelines to implement more sustainable m-learning projects. The term sustainability applied to m-learning may be defined as the ability of the m-learning software to survive the initial stage. Afterwards, mechanisms to be able to maintain the software updated and working must be created [ref, Wingkvist, 2008].

This work is organized as follows: section two analyses the main opportunities and challenges of mobile devices in developing countries. Section three presents the related work regarding m-learning in devolving countries. Section four presents the main guideless to implement more sustainable m-learning projects and their application in the Moodbile project and section five presents the conclusions of this work.

2   MOBILE DEVICES IN DEVELOPING COUNTRIES

2.1   *Factors that have influenced the expansion of mobile technology in developing countries*

One of the factors that have promoted the penetration of mobile telephony in the poorest African countries was the privatization of telephone monopolies in these countries during the 1990s. Since the privatization of state monopolies, private operators that emerged speeded up the introduction of new technology particularly mobile phones. These private companies started to sell mobile phones and calls to an increasingly lower price [8]. This price reduction was one of the factors that led to the expansion of mobile phones in Africa, to the point that now mobile phones represent a technological revolution in Africa, equivalent of the television revolution in the years 1940 in the United States.

Another factor that has helped the spread of mobile phones in poor countries is its ability to keep in touch people who are separated by great distances. For example, members of one family who are forced to separate when the husband emigrates to a big city to find a job and has no fixed place of residence. Mobile phones and wireless networking systems are also ideal for people living in remote areas where no fixed communications infrastructure exists, and that change their place of residence from time to time.

Mobile phones have features that make them different from other ICT. They are relatively inexpensive devices, small, portable and have battery with a strong autonomy. There is a second-hand market that allows people in poor countries to buy a cell phone to a relatively low price. Sometimes several people or groups of people have access to a shared mobile phone [5]. The second hand market, originated in rich countries where people tend to change their mobile phone regularly. The terminals that are not used any more in rich countries go to poor countries, where they are sold at a lower price.

Unlike desktop PCs, mobile phones require fewer infrastructures and are easier to maintain. In places where there is no electricity, recharging the service is offered through street kiosks that charge cell phones with ingenious systems such as car batteries or dynamo powered bicycle. In addition, mobile devices are relatively resistant to heat and dust when compared with desktop PCs.

Although mobiles have greatly simplified the provision of services and reduced the cost of infrastructure, most of the grown has been in urban areas. Mobiles are still expensive to be bought and used by the poor. This slow grown is often hidden (rural statistics are not disaggregated from overall national statistics for example) [8].

2.2   *Disadvantages of mobile technology*

The main disadvantages of this technology are, firstly, the shortage of some of the materials used to make electronic components to manufacture mobile phones (for example coltan). The extraction and exploitation of these materials can and is producing various kinds of conflicts over the control of minerals in the countries where those minerals are extracted (often poor countries) [29].
Secondly, the planned obsolescence of technology (in general and mobile in particular), is another issue. Although there is a second and third hand market for mobile phones in poor countries, at the end, a lot of junk remains and has to be processed [30].
Finally, although many mobile phone manufacturers have incorporated regulations to ensure workers' rights and environmental measures that affect the products they manufacture, these measures often do not apply to subsidiary companies. This is the case of the company called Foxconn located in Taiwan, leading global manufacturer of electronic components; this company has appeared several times in the media due to controversy over how the company treats employees.

3   M-LEARNING FOR DEVELOPMENT

The rapid growth of mobile technologies and services in developing countries make academics and other professionals think that mobile technology has a great potential to help improving education in developing countries and achieving universal primary education (one of the Millennium Goals proposed by the United Nations). Though the Institute for Information Technologies in Education (IITE), UNESCO has made a recent and important strategic commitment to mobile learning, which they see as key enablers in furthering the objectives of Education for All [10]. Mobile technology may also be used to fight against the digital divide and for sustainable development.

The application of mobile technology to support learning is called mobile learning or m-learning. M-learning may be defined as the learning that takes places in different places or that takes advantages of portable technologies. The learner while learning interacts with different types of technology (mobile or fixed) [7].

Since mobile technology is extended in many developing countries it may be used to improve development (this is usually called m-learning4D). This section analyses the related work in this area as well as the challenges that faces m-learning in developing countries.

3.1 Related work

This section presents a review of some m-learning projects for development in developing countries. The bibliography has been organized in the following groups: 1) studies centred in the long-term scalability and sustainability of the m-learning projects, 2) reports of how m-learning can help fight the digital divide, 3) studies to broadcast sustainable development values using mobile devices, 4) studies to promote mobile technologies and the development of mobile services and applications and 5) projects to fight against illiteracy using mobile devices.

Among the studies that promote the importance of scalability and sustainability of m-learning projects, the work of [11] is very relevant. From the teacher point of view the authors developed two initiatives to bring universal primary education to developing countries. The *Digital* Education *Enhancement Project* (DEEP - www.open.ac.uk/deep) carried out an initial study into the potential of ICT for teacher education in developing nations, working with teachers and institutions in Egypt and South Africa.

The SEMA project was started in Kenya in 2003 to support school based teacher development. The project used SMS messages broadcasting for several purposes such as: delivering study guide material, content such as hints, tips or summaries, reminders or urgent messages about errata or cancellations.

Both projects analyse the impact of mobile technologies in the pedagogy of teachers. Both projects use different hardware: the DEEP project uses PDAS and laptops while the SEMA project uses GSM mobile phones. Both projects conclude that the long temp sustainability of the project is one of the challenges of m-learning in Africa. A Study conducted in the *Vinayaka Missions Distance University*, studies how mobile technology may affect sustainable distance education in a multicultural context [12]. Some students of History, Economical and Political sciences where given the opportunity to participate in an experiment conducted in the subject of public politics. The contents of the subject where organized in lessons and each student participating in the pilot had to prepare a list of questions and answers for a specific lesson. Besides, each student received the list of lessons prepared by the other students. Mobile phones where used to send the lists of questions and answers as SMS messages and attached word files. Discussions forums where used among students to discuss the different lessons. The conclusions of this study are that students that participated in the experiment got better grades than the rest. In this study, mobile devices are used to enhance collaboration and interaction.

Among the studies to fight against the digital divide using mobile devices, two of them [13] and [14] suggest that it is important to find strategies to implement low-cost m-learning projects. Litchfield and his colleges propose some work directions in order to use m-learning to fight against the digital divide [13]. They consider that some of the initial expectations of m-learning in developing countries have not been achieved because the projects are not yet consolidated. There may be needed a larger period of time to analyse the results of these projects.

According to the previous authors, two strategies to fight against the digital divide are needed: 1) international community must promote initiatives to take low-cost tech to poor countries and 2) poor countries must understand that tech is related to development. They must start implement low-cost viable and mid term projects.

From the learner point of view, Brown proposes a model for m-learning in Africa [15]. He states that m-learning may help learners from third world rural or remote areas who have access to a mobile phone. The University of Pretoria (South Africa) started a m-learning pilot project at 2002. Three existing programmes of the Faculty of Education adopted the m-learning pilot project. This pilot project was launched based on the fact that 99% of the students had mobile phones and that most of them lived in rural areas with no fixed ICT infrastructure. The pilot project used bulk SMS to provide students with basic administrative support. The SMS focussed on reminders of important dates for activities like contact classes or examination registration as well as notification of study material distribution.

The project was successful because learners responded in mass and almost immediately on information provided in SMS-messages. Instead of using SMS bulks, using print and postal service to distribute the necessary information to students, would have been more than 20 times the cost of the bulk SMS. While SMSs provided just-in-time information, the posted information would have taken between 3 and 18 days to reach the learners. Some conclusions of the project were that: 1) m-learning is a supportive mode of education, 2) m-learning provides flexibilies for various learning and lifestyles and 3) the most appropriate mobile device for learners in Africa is the mobile phone.

The project One Laptop Per Child (OLPC) is another initiative to fight against the digital divide between rich and poor countries. The main goal of this project is to give the poorest children of the world one low cost computer to help them take advantages of ICTs. With this idea in mind, a new small durable laptop was created. This laptop has unique innovative features such as a unique design, resistance to adverse weather conditions, high autonomous battery, open source software and new minimalist interface. Howerver, the OLPC project has some critics, being the main one that the OLPC project is solely a technological solution without an educational approach [16]. Since it is not an educational project there are not pilots that may be used as reference to evaluate the use of this laptop to fight the digital divide. Another problem of the OLPC laptop is its distribution model. In order to take advantage of scale economies and be able to sell the laptop for a low price, the countries that are interested in buying the laptop must buy large orders. This is a serious drawback because many countries are reticent to invest large amounts of money in this laptop especially when other companies offer them similar laptops (such as Asus Educational PC) for a low price.

The MobiED project consisted in the creation of a audio Wikipedia [17]. The users may send term queries to the Wikipedia server using SMS messages from their mobile phones. The server answers the query with a phone call where

a synthesizer reads the answers. If the term is not found, the user may contribute by dictating its definition. Due to the good results of the study, authors explore the possibility of using m-learning as a de-facto platform in Africa.

Other projects [18-19] study how to broadcast sustainable development values using mobile technology as support systems. Chen and Hsu designed a m-learning module for sustainability in education [18]. A mobile device carrying self-guiding trip instructions was given to 14-year-old students to conduct a field trip without the company of the teacher. The goal was to visit 5 view points showing various environmental problems in Taipei (Taiwan), caused by bad usage of natural resources. The students were asked to collect field data such as pictures or interview local residents to evaluate 3 scenarios regarding the future development of the affected zone. The results of this study showed that both teachers and students agreed that the m-learning application had helped them understand local environmental issues as well as concepts of sustainable development. The project UbiGreen is an initiative to analyse the transport habits in two North American cities [19]. The study starts posing two tests (one online and the other mobile) to the people that participates in the study. The people participating in the study are interested in changing their habits to be more ecologic. Another goal of the study is to know which is the main motivation to drive to work instead of taking public transport. The results of these polls are used to design a mobile application called *UbiGreen Transportation Display* that semi-automatically gets information about transportation habits of the person carrying the mobile phone. The main goal of this application is motivate people to use more ecological means of transportation.

Mekuria and his colleges described a master in mobile computing developed at the Makerere University (Uganda) that will help develop more advanced mobile services adapted to the socio-economic situation of developing countries [20-21]. This master programmes provide students with knowledge to develop software applications and services for mobile devices as well as to promote sustainable development because:

Students that finish the programme go back to their home village with a mobile service to be tested by the people of the village. Students learn important knowledge to develop mobile services. Another project to promote studies to create mobile services is Mobitel [22]. It is the first national mobile service provider in SriLanka. Mobitel first trialled a m-learning platform facilitating the Faculty of Graduate Studies, at the University of Colombo to deliver its diploma in marketing via m-learning. Following the success of the trial the m-learning platform was extended to more faculties.

Finally, other projects are centred in helping improving literacy (mobilink) or skills in specific subjects such as maths (Momaths) or English (Janala) [22]. Kim studies the possibility of introducing m-learning activities in groups of very poor children of South America [27]. These children usually live in remote areas and have an itinerant life due to their parents work. They do not have access to primary education and reading materials. Their parents are also illiterate and have no possibilities to help their children. The main goal of this study is to analyse the social phenomenon of introducing m-learning activities in this context to help children learn to read. The experiment conducted consisted in giving these children mobile phones loaded with educational activities for children between 3 and 13 years old. The activities included activities to learn the alphabet as well as other reading activities. Some of the conclusions of the study are that children learned very quickly (in minutes) how to use the mobile phone. Older children hat could read were able to tell the others the stories at the same speed as if they were reading in a book. These activities were amusing for children and provided them with access to some reading materials.

3.2   Challenges of m-learning projects

Some of the challenges that faces m-learning initiatives have been analysed previously [13][23]. Some of them are summarized below.

- Partial opposition to change the traditional practices of educational institutions.
- No motivation to change technology because many times it involves new requirements and change the way of doing things.
- Need to spend much time in customizing and adapting materials and content to different types of devices or platforms.
- The cost of introducing m-learning is still high because hardware and Internet connections are still expensive. It is necessary to find low-cost solutions to maintain product sustainability.
- Mobile phone companies show little interest in sharing knowledge and applications because it does not have a direct benefit.
- Many of the m-learning projects are pilots or small scale projects. It is necessary to define projects with more impact
- It is necessary to consider that there are different socio-cultural realities in order to create content and services for developing countries.

4 INTEGRATION OF M-LEARNING WITH OTHER ICT FROM A SUSTAINABLE PERSPECTIVE

4.1 Trends of m-learning for development

According to [24] in the near future the application of ICT for development is focused on 1) research on mobile devices, 2) evaluation of the potential of web 2.0 and FOSS for poor communities, 3) study the integration of different types of ICTs, 4) research in order to create more resources for poor local communities. These ideas have been adapted to identify several key aspects that may contribute to create more sustainable m-learning projects.

To overcome some of the challenges that face many m-learning projects the integration of m-learning tools with other ICTs (such e-learning platforms) could be useful. This extension could extend the scope of the m-learning tool because many educational institutions already use an e-learning platform. According to [10] mobile learning applications are most powerful when they are linked to an institutions LMS compatible with mobile devices.

Another idea to have more successful m-learning projects is achieve local participation and collaboration. This idea is borrowed from Web 2.0 and FOSS practices. One of the characteristics of the social revolution of Web 2.0 is that Internet users may no longer be passive information consumers; they may become information or content creators. This change is affecting people all over the world, including developing countries. More active users that participate in the creation of information and knowledge arise. Moreover, according to [25], Web 2.0 and FOSS practices have several elements in common, because collaboration and sharing of information are also characteristics of the FOSS movement. Nowadays, there are many open source tools to engage collaboration and participation, available for a very low cost. Theses tools allow the poor to spread their message.

Finally, more resources and contents are needed for mobile devices. These contents must be appropriate for local communities needs.

In summary, the previous points may help overcome some of the challenges of m-learning projects such as the adaptation of contents and services to mobile devices and the sustainability of m-learning projects once the initial stage finishes.

4.2 Guidelines to define more sustainable m-learning projects

To improve the implementation of m-learning projects, the authors propose a series of guidelines that are described below:
- Engage local motivation and participation: It is important that the community must have shown its interest and motivation for the project and that it will indeed be used.
- Promote education in ICT and development of local capacities. The community members will need some sort of training exposure to ICT to further their understanding of the project. They need basic training on how use mobile phones, the software and on handling information and services provided by these devices.
- Collaboration with external participants. This may be interesting especially at the beginning of the project where external funding are needed to start the project.
- Create a plan to guarantee financial viability in order to guarantee the project's sustainability.
- Use mobile technology as basic platform: the main technological component must be mobile phones, because it is the only ICT that most of the people in developing countries have access to.
- Use FOSS software. To promote FOSS, advantages of using this type of software should be explained as well as the multiple FOSS tools available on the Internet. Furthermore, the development of m-learning projects should be based on participation and collaboration.
- Localize the software: The software used must be able to adapt to the language of local people. Otherwise, it may not be used at all.
- Update the software locally: the ability to be able to update and maintain the system with local capacity.
- Scale the software locally: once the pilot project has finished the project must have a plan to maintain its sustainability. It may have to be enlarged. This must be done locally.
- Local ownership. Some approaches to the implementation of m-learning have included sponsorship from device manufacturers which has enabled organizations to provide whole cohorts of learners with devices. Although this is useful, it raises issues of ownership and sustainability. Another approach to provide devices to learners is assisting them to buy an inexpensive device [10].

5 CASE STUDY: THE MOODBILE PROJECT

The Moodbile project (http://moodbile.org) aims to enable mobile learning applications to work together with the LMS Moodle. Moodbile has two main goals: 1) create a Moodle extension to enable the creation of mobile applications that replicate some of the functionalities offered by the LMS and 2) provide a framework so that mobile applications have a counterpart in Moodle (for instance as special activities that can communicate with the mobile application) [26].

This project is an integration proposal to integrate m-learning applications with the LMS, so that m-learning applications can widen their scope and traditional LMS can still be a source of innovation.

The motivation of the Moodbile project is to open up the most commonly used e-learning platforms and LMS, originally designed as monolithic or layered systems, to the service paradigm and to mobile world [30].

In summary, the Moodbile project provides: 1) an extension of the Moodle webservice architecture to allow the interaction with external applications such as m-learning applications, 2) documentation of the Moodle functionalities provided as services by this extension and 3) the implementation of three mobile clients (an HTML5, Android-native and Ios-native) applications that validates the extension [31].

The Moodbile project follows the guidelines defined previously to implement more sustainable m-learning projects because:

- It is a collaborative project because it has been released as an open source project and as most open source projects it tries to promote collaboration. It creates an extensible services layer for Moodle that allows this LMS to interact with external applications. Third parts may extend this layer easily.
- Moodbile is an m-learning project that provides documentation about the Moodle extension designed and the mobile clients so that others can extend this work.
- This project has been developed by the SUSHITOS (http://sushitos.essi.upc.edu/) research group in col.laboration with the GRIAL (http://grial.usal.es/) reserach group GRIAL of the Salamanca University and UPCnet (http://www.upcnet.es/).
- There is long term viability plan for the project because it is the technological base for other research projects that use the Moodle extension designed for Moodbile. These projects contribute to Moodbile with financial efforts.
- Mobile technology is the basic ICT platform of the project.
- It is an open source project.
- Moodbile has language extensions that allows its internationalization. Moodbile clients may be translated to all the languages available for the Moodle platform.
- The Moodle extension has an architecture that allows its scalability. New functionalities and connection methods can be added.
- The project may be updated and improved using the base code.
- In part, Moodbile has been created to solve Moodle usability problems in the small screen of mobile devices.

6 CONCLUSIONS

The Moodbile project aims to address the separation between the e-learning platforms and the m-learning world, proposing a solution to integrate the m-learning applications with an OS LMS, Moodle. This projects tries to follow the previously defined guidelines to create more long-term m-learning sustainable projects.

The future research includes the following research activities: 1) Create pilots to validate the proposal, 2) Introduce student-centred activities in Moodbile. These activities will take advantage of the mobile phone unique capabilities. They will also have a counter part in the LMS side (as mobile activities). Finally 3) evolve the current version of the project to create a mobile LMS.

REFERENCES

[1]   United Nations, "Informe para el Desarrollo humano 2001." 2001.

[2]   UNESCO, "United Nations Decade of Education for Sustainable Development (DESD)." Unesco Institute for Lifelong Learning, 2005.

[3]   WSIS, "World summit on the Information Society." 2005.

[4]   ITU, "The World in 2011: ICT Facts and Figures." International Telecommunication Union (ITU), 2011.

[5]   K. Banks, "Mobile Phones and the Digital Divide," *PCWorld*, 2008.

[6]   I. Peña-López, "Mobile Web for Development." In ICTlogy, #63, 2008.

[7]   M. Sharples, "Big issues in mobile learning," *Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative. Nottingham*, 2006.

[8]   M. Shanmugavelan, K. Warnock, and D. De Sarkar, *Completing the revolution: The challenge of rural telephony in Africa*. Communication for Development Programme, Panos Institute, 2009.

[10]   GSMA, "Mobile Education Landscape Report." GSMA Development Fund, 2011.

[11]   J. Traxler and J. Leach, "Innovative and sustainable mobile learning in Africa," 2006, pp. 98–102.

[12]   S. Chandran, "Sustainable Distance Education Through Mobile Learning: A Case Study in Multicultural Context," *OIDA International Journal of Sustainable Development*, vol. 2, no. 3, pp. 35–40, 2010.

[13]   A. Litchfield, L. Dyson, E. Lawrence, and A. Zmijewska, "Directions for m-learning research to enhance active learning," *ICT: Providing choices for learners and learning.Proceedings ASCILITE*, 2007.

[14]   Y. Laouris and R. Laouri, "Can Information and Mobile Technologies Serve to Close the Economic, Educational, Digital, and Social gaps and Accelerate Development?," *World Futures*, vol. 64, no. 4, pp. 254–275, 2008.

[15]   T. H. Brown, "Towards a model for m-learning in Africa," *International Journal on E-Learning*, vol. 4, no. 3, p. 299, 2005.

[16]   J. Camfield, A. Kobulsky, J. Paris, and N. Vonortas, "A Report Card for One Laptop Per Child," *Closing the Digital Divide via ICTs and Education: Successes and Failures. joncamfield. com/writing/Camfield_Report_Card_for_OLPC. pdf*, vol. 6, p. 2008, 2007.

[17]   S. Chan and N. Ford, "Mlearning and the workplace learner: integrating mlearning eportfolios with moodle'," 2007.

[18]   C. Chen and T. Hsu, "Learning Sustainable Development With Mobile Devices," in *Proceedings of Geographical Views on Education for Sustainable Development*, Lucerna, 2007.

[19]   J. Froehlich, T. Dillahunt, P. Klasnja, J. Mankoff, S. Consolvo, B. Harrison, and J. A. Landay, "UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits," in *Proceedings of the 27th international conference on Human factors in computing systems*, 2009, pp. 1043–1052.

[20]   F. Mekuria, "Using Mobile Technology and Services for Sustainable Development in Africa," *Strengthening the Role of ICT in Development*, p. 290, 2008.

[21]   F. Mekuria and I. Rai, "Issues in Next Generation Wireless Network Technologies & Services for Developing Regions," *Proc. of Mobicom-08, WiNS-DR*, 2008.

[22]   GSMA, "mLearning: A Platform for Educational Opportunities at the Base of the Pyramid." GSMA Development Fund, 2010.

[23]   B. Zuga, I. Slaidins, A. Kapenieks, and A. Strazds, "M-learning and mobile knowledge management: similarities and differences," *International Journal of Computing & Information Sciences*, vol. 4, no. 2, pp. 58–62, 2006.

[24]   R. Heeks, *The ICT4D 2.0 Manifesto: Where Next for ICTs and International Development?* University of Manchester, Institute for Development Policy and Management, 2009.

[25]   B. K. Thomas, "Participation in the Knowledge Society: the Free and Open Source Software (FOSS) movement compared with participatory development," *Development in Practice*, vol. 20, no. 2, pp. 270–276, 2010.

[26]   M. J. Casany, M. Alier, E. Mayol, J. Piguillem, N. Galanis, M. Á. Conde, and F. J. García-Peñalvo, "Moodbile: A Framework to integrate m-learning applications with the LMS," *In Journal of Research and Practice in Information Technology*, 2012 (in press).

[27]   P. Kim, T. Miranda & C. Olaciregui, "Pocket School: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America". *In International Journal of Education Development*, 28, 435-445, 2008.

 [28]   S. Aparicio, "La guerra del Coltan". *In el Mundo,* 2003. Available at: http://www.elmundo.es/documentos/2003/04/guerras_olvidadas/congo.html (accessed July 2012)

[29] J. Mooallem, "The afterlife of Cellphones". In *New York Times,* 2008.

[30]   M. J. Casany, M. Alier, E. Mayol, J. Piguillem, N. Galanis, F. J. García-Peñalvo and M.Á. Conde, *"*Extending Moodle services to mobile devices: the Moodbile project*". In Proceedings of the International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (Ubicomm 2012),* 2012*,* (in press).

[31]   J. Piguillem, M. Alier, M. J. Casany, E. Mayol, N. Galanis, F. J. García-Peñalvo and M. Á. Conde, "Moodbile: a Moodle web services extension for mobile applications". *In Proceedings of the First Moodle Research Conference,* 2012 (in press).

[32]   M-learning: A platform for educational opportunities at the base of the pyramid. http://www.mobileactive.org/files/file_uploads/mLearning_Report_Final_Dec2010.pdf

[33] M-learning for Development: tools. http://www.ml4d.org/kb/tools

[34] http://tonydwisusanto.files.wordpress.com/2007/12/opportunity.pdf

[35] http://cs.joensuu.fi/sipu/2011_MSc_Jaiswal_Pankaj.pdf