

A Suitable m-Learning System using e-Book for Developing Countries

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Abstract: While large scale online courses such as MOOCs are popular in developed countries, their dissemination is difficult in developing countries due to the existing challenges faced by the digital divide such as poverty, internet accessibility, and the low PC ownership ratio. A learning platform for mobile learning was developed for developing countries where people often have no access to the Internet. The platform is called creative higher education with learning objects (CHiLO) and was developed with the aim of solving the problem. As a demonstration experiment, we distributed CHiLO books of the NSA1 series in about one year (from April 2014 to March 2015), 47% of over 20,000 downloaded books were from developing countries. Our experimental results in Japan have indicated the potential effectiveness of CHiLO for developing countries.

1 INTRODUCTION

Large scale online courses such as Massive Open Online Courses (MOOCs) can strongly contribute to enhancing the opportunities for higher education around the world. Additionally, they help create a new learning artifact or ecosystem, whilst sharing personal knowledge (Siemens, 2013).

Ally and Samaka (2013) stated that a major issue in developing countries' education systems is the shortage of teachers and actual, physical schools for students to attend. An opportunity currently exists for a transformation in education, where fewer teachers are required and learning materials are delivered to learners within their communities rather than sending learners to physical schools.

MOOCs can be potentially effective in bridging the educational inequality between countries. Nevertheless, Liyanagunawardena et al. (2013A) reported that most learners of MOOCs were from North America and Europe in 2012. The reason is the existing challenges of the digital divide. Khan et al (2012) stated that online education in developing countries has two barriers. The barriers are

categorized as external and internal. The internal barriers include lack of equipment, unreliability of equipment, lack of technical support, and other resource-related issues. The external barriers include both school-level factors, such as organizational culture, and teacher-level factors, such as beliefs about teaching, technology, and openness to change.

For this particular study, we focused on the recent trend of mobile devices, such as the rapid growth of smart phones and tablet PCs all over the world, including many developing countries. The development of a new learning platform called Creative Higher Education with Learning Objects (CHiLO) uses an e-book that can accessed on many mobile devices and does not always have to be connected to a network environment.

In this study, we report on the possibilities for CHiLO as a flexible and diversified learning platform. Our experiment provides evidence of the effectiveness of mobile devices as a delivery system for e-books.

2 CHALLENGE OF MOOCS IN THE DEVELOPING WORLD

2.1 Digital Divide

Generally speaking, an MOOC is categorized into two models; xMOOC and cMOOC. The xMOOC model is based on a well-defined sequence of learning content, mainly video lectures and interactive self-tests, with heavy reliance on social collaboration features (Grünewald et al., 2013). Many of the MOOCs, such as xMOOCs, primarily comprise little in the way of external materials and rely on more traditional learning, with the use of video lectures, quizzes, and exams (McGreal et al., 2013). These inflexible traditional Learning Management Systems (LMS) require substantial and sustainable connections and relatively high bandwidth (Mott, 2010).

Furthermore, only 32.9% of households in developing countries have a computer, whereas this figure is 80.8% in developed countries (ITU, 2015). People in remote locations and developing countries are in a situation where they have difficulty accessing online learning environments such as xMOOCs (Ally and Samaka, 2013).

2.2 Learners' Culture and Context

In terms of inflexibility, MOOCs have two challenges; content and LMS.

Regarding content, despite the need for learners in developing countries to have localized content in each country, learners often only make use of MOOCs for their own learning and do not reuse them as a platform for becoming educators themselves (Adams, 2013). MOOC curricula, which are generally developed by professors at elite institutions, do not address the needs of students in what Gunawardena terms "If the needs of students in developing countries aren't properly considered, then MOOCs become not a help but a hindrance." (Gunawardena, 2014). For people in developing countries, more flexibility is required for the use, reuse, and adaptation of materials for local contexts and learning environments (UNESCO, 2015).

Additionally, there is the language barrier. It is difficult for non-native English speakers to actively participate in forums in the many English-dominated MOOCs (Liyanagunawardena et al., 2013B).

The second challenge lies in the area where most MOOCs use traditional LMS, which are designed as course-centric or time-based systems around content delivery, course delivery and the mechanics of running a course tailored to traditional classrooms

(Liyanage et al., 2013). However, in large scale online courses such as MOOCs, the traditional face-to-face teaching approach is impossible for a number of learners. MOOCs face challenges in motivating learners and managing system operations because the LMS adheres to conventional technology and methods. Therefore, traditional LMS do not fulfill the requirements of these large scale online courses.

3 RELATED WORKS

3.1 m-Learning

Mobile devices in developing countries have grown remarkably in recent years.

Figure 1 shows active mobile-broadband subscriptions for developed countries and developing countries (ITU, 2015). The subscriptions for developing countries are rising rapidly in both the overall number and percentage, when compared to developed countries.

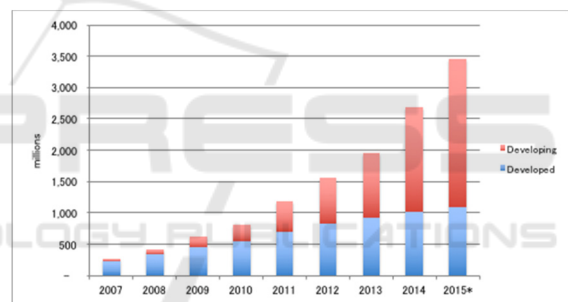


Figure 1: Active mobile-broadband subscriptions of developed countries and developing countries (ITU, 2015).

Mobile devices have the following benefits:

- **Affordability of Demand-Side:** The many pricing models offer affordability and choice, even for very low-income customers (cheap handsets, micro prepayments, top-up cards) (Bhavnani, 2008).
- **Reduction of Electricity Problems:** Mobile devices do not necessarily require a stable power supply (Georgiev et al., 2004).
- **Several Communication Options:** Mobile devices can be utilized through several communication technologies such as global system for mobile communications (GSM), wireless application protocol (WAP), and Bluetooth, without a permanent physical connection to cable networks (Georgiev et al., 2004).

- **Ease of Use:** Mobile devices are easy to use without the need for computer skills (Bhavvani, 2008, Floro, 2011).
- **Pervasive and Ubiquitous:** Mobile devices are pervasive and ubiquitous and are increasingly changing the nature of obtaining knowledge in modern societies (Georgiev et al., 2004, Traxler, 2007).

Mobile learning (m-learning) can be defined as a combination product of mobile technology and e-Learning technology (Khan et al., 2012).

A project titled “Mobile Online Learning for Human Rights” was conducted in cooperation with the Kenya Human Rights Commission (KHRC). The primary goal was to create a platform to freely spread information about human rights to any Kenyan in order to increase knowledge and engagement. The research goals of this project were to explore the viability of using MOOC with incentives to reach, engage and educate (Jobe and Hansson, 2013).

The Digital Ubiquitous Mobile Broadband, OLSR (DUMBO) project, initiated by the Asian Institute of Technology Internet Education and Research Laboratory, developed and tested a system for emergency scenario response in Thailand. Adapting the concept of wireless mesh networks, DUMBO used lightweight portable mobile nodes to broaden coverage and penetrate deep into areas not accessible by roads, or where the telecommunication infrastructure had been destroyed (Kanchanasut et al., 2007). Where traditional wired infrastructure has been avoided due to prohibitive costs and unsympathetic geography, wireless technologies are attractive to governments, NGOs and operators because they can be deployed in an inexpensive, decentralized and effective manner, when compared to other solutions (Stan, 2011).

3.2 e-Book and EDUPUB

An e-book has the advantage of being easily carried in a portable device—a mobile phone or tablet PC—without a network. Using e-books provides a new way of learning adapted to the network-learning model. The e-book, which is not only device independent but is also available off or online, has adopted the m-learning strategy. Furthermore, e-books have the interoperability of EPUB and major e-book formats, namely Kindle’s K8 format, iBooks format, and others (Bläsi and Rothlauf, 2013).

EPUB3 is a distribution and interchange format standard for e-books, developed by the International Digital Publishing Forum (IDPF) (Polanka, 2013). The advent of the EPUB3 format has meant that e-

books now include media-rich and interactive content. The IDPF 2015 defined this capability as follows: “The EPUB specification is a distribution and interchange format standard for digital publications and documents. EPUB defines a means of representing, packaging, and encoding structured and semantically enhanced web content—including HTML5, CSS, SVG, images and other resources—for distribution in a single-file format.” Thus, the EPUB3 format has greater sourcing flexibility. In the field of education, learning materials in the EPUB3 format are easily repurposed by tutors, adapted to improve learning outcomes, and offer a way of avoiding vendor lock-in (Belfanti, 2014).

The IDPF has proposed the EDUPUB format to meet the requirements of next-generation learning content on the basis of the e-book EPUB3 format (IDPF, 2014). EDUPUB implemented a system for cooperation with LMS, Analytics Systems, Student Information Systems (SIS), and assessment systems on EPUB3 using JavaScript and JavaScript Object Notation (JSON) (Figure 2). EUPUB has the following benefits (Belfanti, 2014) in that it can:

- Achieve economies-of-scale in design, development, and distribution
- Ensure highest quality across multiple platforms and devices
- Integrate with LMS and other services
- Be repurposed by teachers
- Offer flexibility: it can be used in both the classroom/off-campus and online/offline environments, on mobile devices and PCs

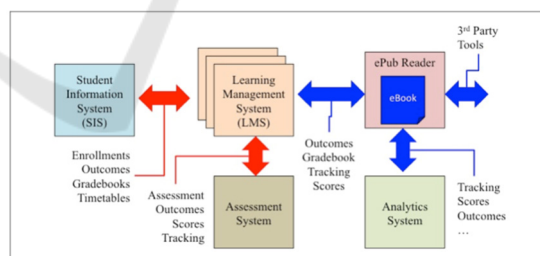


Figure 2: Overarching EDUPUB Architectural Model (IDPF, 2014).

E-books are now being introduced into education, and their improvement has been widely studied. EDUPUB is one of the more superior solutions; however, the implementation of these applications is still being discussed. Furthermore, EUPUB has not been heavily focused on use in rural areas.

3.3 Subdivision of the Course

Competency-Based education (CBE) is an approach

to learning that focuses on the student’s ability to demonstrate the desired learning outcomes as central to the learning process. Through this approach, learners can acquire the learning content based on their own competencies and at their own pace, receiving timely, individualized support with short-term learning strategies (Sturgis et al., 2011).

An approach used by MIT is known as the “unbundling of education.” This approach tries to unbundle the functional elements of education as modules, and then re-bundles each module with assessment methods, or on the basis of the learners’ needs (MIT, 2013). The NanoDegree rendered by Udacity, a for-profit educational organization, or a MOOC platform, provides learners with a bite-sized bundle of knowledge and more immediate motivation for acquiring a degree.

What these approaches have in common is that they split courses, which are delivered by MOOC, into smaller learning components to which learners are provided access. MIT Task Force (2013) also outlined that “As seen in recent online educational trends, learning content is split into smaller units, which are then reassembled to allow self-paced and self-path learning.”

This kind of method, in which a certain index of tasks to be taught and learned is created, has been practiced for a long time as Goal analysis in the field of Instructional Design (ID).

As a recent trend in online education, the method above has progressed to make the learning outcomes of tasks measurable and to offer more variety in education by combining the tasks.

4 DEVELOPMENT OF CHILO BASED ON E-BOOK

4.1 Framework

CHiLO provides flexible, diversified services for online learning based on various computer network environments, devices, learners’ skills with e-books, CBE, digital badges, and social learning (Figure 3). It comprises the following four components:

- **CHiLO Books** using e-textbooks in EPUB3 format
- **CHiLO Lectures** based on one-minute nano lectures
- **CHiLO Badges** providing authentication and certification
- **CHiLO Communities** such as social networking services (SNS), bulletin boards, and chat rooms

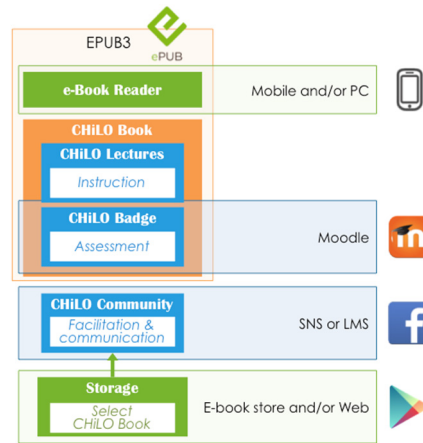


Figure 3: Components of CHiLO.

4.2 CHiLO’s Learning Components

4.2.1 The CHiLO Book

CHiLO books, a core CHiLO component created using EPUB3 e-books, contain media-rich content, including graphics, animation, audio, and embedded video. Based on the micro-credential method, CHiLO books comprise learning materials used during a classroom hour. On completing a CHiLO book, a CHiLO badge is given as a certificate of completion.

The CHiLO Book is created through an e-book with an EPUB3 format and HTML5 format. The EPUB3-based CHiLO Book ensures access to a learning environment without an internet connection and is also available through e-book stores. In contrast, the HTML5-based CHiLO book is very convenient for learners who have constant internet access.

4.2.2 The CHiLO Lecture

CHiLO lectures contain videos with scripts, quizzes, and other learning materials. Videos offer one-minute nano lectures. This concept emerged from an experiment revealing that online learners’ average viewing time is approximately one minute (Hori et al., 2013). A CHiLO lecture is equivalent to one section in a traditional textbook. A CHiLO book contains approximately 10 CHiLO lectures, and a standard CHiLO course, which is comparable to a traditional university course with one academic credit, comprises 10 CHiLO books.

4.2.3 The CHiLO Badge

The outcome assessment of a CHiLO book, which includes CHiLO lectures, involves the use of CHiLO

badges. This assessment tool directly measures knowledge and learning, rather than linking it to seat time and grades, such as taking tests and/or completing reports. The CHiLO badge assumes the role of a certificate of assessment.

Each of the assessment instruments is implemented by utilizing activity modules from Moodle. In Moodle, there is a variety of evaluation methods available; such as the Quiz activity module, grading of reports, posting messages in the Forum activity module and so on. Furthermore, we can issue digital badges by setting a certain criteria on those evaluations.

4.2.4 CHiLO Community

The CHiLO community functions as a social network. Learners may share a downloaded CHiLO book and discuss on an open SNS on the Internet, e.g., Facebook and Twitter.

The CHiLO community is comprised of many learners and a few tutors, known as “connoisseurs.” These tutors act as substitutes for teachers. A learner who has studied and completed CHiLO books in a specific field can become a connoisseur. Connoisseurs and learners are on equal footing; the connoisseur often exchanges information with learners in the community.

In the CHiLO community, a learner does not learn from a tutor but rather learns independently using CHiLO books as a learning resource. Thus, learners are constantly required to find suitable CHiLO books within the community. The CHiLO community provides methods for discovering, sharing, aggregating, and repurposing CHiLO books for learners.

4.2.5 The CHiLO Producer

In order to create CHiLO Books, we developed the CHiLO Producer, which is a Java 8-based application tool. Given that the web-based CHiLO Book is composed of HTML5-based resources, it is relatively easy to output both web-based CHiLO lectures and HTML5-based ones simultaneously. In addition, the outputs can be saved as CHiLO books in some storage systems that have the capability to deploy the outputs to a wide range of learners.

Since the CHiLO Book is based on standard EPUB3 format, it is possible to distribute the packaged content through common e-book stores such as Apple Store and Google Play. We have chosen these two at this time.

5 APPLYING THE CHILO FRAMEWORK

5.1 An Experimental Methodology

We produced a series of CHiLO Books titled “Nihongo Starter A1 (NS A1),” in cooperation with the Open University of Japan (OUJ) and the Japan Foundation, and delivered them as a learning course of OUJ MOOC in JMOOC. JMOOC “is an organization that was formed in 2013 with the cooperation of Japanese universities and businesses that aims to spread and magnify Japanese MOOCs throughout the country” (see <http://www.jmooc.jp/en/about/>).

5.1.1 Design and Development

NS A1, which has been designed based on JF Japanese Education Standards, is a course for beginners in Japanese. As a demonstration experiment, we distributed CHiLO Books of the NS A1 series over a time frame of approximately one year (from April 2014 to March 2015). Each CHiLO Book was deployed free of charge via three different storage units, or distribution channels, as shown in Table 1.

Table 1: NS A1 CHiLO Book Storage.

Storage unit	EPUB3-based	Web-based
OUJ-MOOC site	√	√
iBooks Store (Apple Store)	√	N/A
Google Play Books	√	N/A

During the period of this experiment, we created groups on Facebook as a CHiLO Community, and invited learners to the communities in five different periods. In order to facilitate discussions and question-and-answer sessions among each community, we organized support teams and assigned staff to each community/class in each term.

5.2 Experimental Results

Table 2 shows the total number of downloads of the NS A1 CHiLO Books. The numbers were determined based on unique users and was divided by countries and regions that are classified by United Nation in 2012.

Although people in some countries and regions were legally restricted from downloading an e-book through iBooks Store and Google Play Books, in this

demonstration experiment, we found that CHiLO Books were downloaded in 103 countries and regions: Google Play Books in 46 countries, iBooks Store in 34 countries, EPUB from OUI-MOOC in 94 and HTML5 from OUI-MOOC in 86 countries and regions. Specifically, CHiLO Books were frequently downloaded in rural areas: Indonesia (2,022), Thailand (1,384), Philippines (1,201), Mexico (710), Malaysia (690), Colombia (678), and Brazil (499).

From the results, we can assume that the CHiLO Book, and its format, might appeal to people in rural areas.

Table 2: Number of downloads of NS A1 CHiLO Books.

	Total	Google EPUB3	iBooks EPUB3	OUI EPUB3	OUI Web
U.S. (Developed)	3,625	1,214	1,844	275	292
Indonesia (Developing)	2,022	1,578	0	259	185
Japan (Developed)	1,833	488	701	300	344
Thailand (Developing)	1,384	1,308	0	51	25
Philippines (Developing)	1,201	826	0	203	172
Mexico (Developing)	710	88	164	319	139
Malaysia (Developing)	690	541	0	60	89
Colombia (Developing)	678	14	31	330	303
Venezuela (Developed)	532	16	11	253	252
Brazil (Developing)	499	183	69	114	133
Other (93)	8,954	2,114	895	2,968	2,977
Total (103)	22,128	8,370	3,715	5,132	4,911

Regarding our analysis of device-specific access to the Moodle quiz module, 56.1% (1,771) accessed it from PCs, 18.1% (572) from tablet PCs, and 25.8% (831) from smartphones (Figure 4).

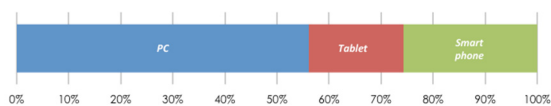


Figure 4: Ratio of traffic of quizzes in each CHiLO Book by device.

Furthermore, we divided the access logs into EPUB3-based and web-based CHiLO Books. In the

case of web-based books, approximately 69% of access was from PCs; in the case of EPUB3-based books, approximately 73% of access was from mobile devices, such as smartphones and tablet PCs (Figure 5).

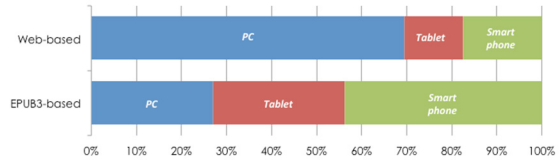


Figure 5: Ratio of people who responded to the questionnaire by the CHiLO Book format and devices.

6 ANALYSIS AND DISCUSSION

6.1 An Availability of Developing Countries

3,040 learners in the CHiLO Community on Facebook participated in our experiments throughout five classes. 22,128 CHiLO Books were downloaded by learners from 103 countries in the same time period.

Table 3 shows the number of downloads of CHiLO Books by distribution channel.

Table 3: Number of downloads of NS A1 CHiLO Books by distribution channel.

Storage	Number of downloads	
Google: EPUB3	8,370	17,217
iBooks: EPUB3	3,715	
OUI: EPUB3	5,132	
OUI: Web	4,911	4,911
Total		22,128

Of the downloaded CHiLO Books, 47% were from developing countries. This percentage exceeds the 34% of enrolments in HarvardX's 17 courses as of August, 2013 (see <http://harvardx.harvard.edu/harvardx-insights>).

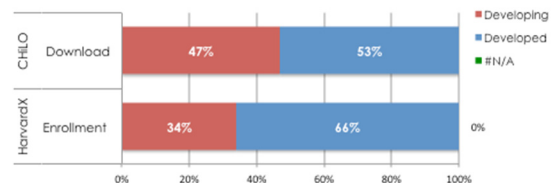


Figure 6: Downloads from UN Developing Countries.

6.2 Device Use

In this demonstration experiment, more than half, 56.1% of the learners utilized PCs. Results indicated that the learners showed a tendency to choose the web format, if they were PC users, and e-book format if they were mobile device users (Figure 4, Figure 5). 16.2 % of learners studied mainly using the e-book format, whilst 49.5% studied using the web format and 34.3% studied using both formats. These results were derived from questionnaires completed by those who had earned badges during this demonstration experiment (Table 4).

Table 4: Questionnaire results: Which CHiLO Book did you use: EPUB3-based or web-based CHiLO Book? (n = 105).

Mostly used the eBook version	17	16.2%
Mainly the eBook version, sometimes the web version	13	34.3%
Used both the eBook version and the web version at the same rate	6	
Mainly the web version, sometimes the eBook version	17	49.5%
Mostly used the web version	52	

6.3 Learning Community on SNS

In the CHiLO Community on Facebook, many participants posted that they were happy with the community and showed off the badges they had achieved. Participants who had completed the series tended to provide helpful suggestions to the next group of participants. Additionally, some of the Spanish-speaking learners volunteered to form a learning group in which they translated the CHiLO Books into Spanish.

These results indicate that a learning community may play a significant role in the online learning environment as well as the traditional learning environment.

An online learning system not only provides learning content, it can also provide a learning environment. CHiLO provides an essential online learning system, within which the CHiLO Community provides the learning environment and the CHiLO Book provides the learning content.

7 CONCLUSION

We created CHiLO for people living in developing countries, who cannot be continuously connected to the internet or who do not have PCs.

In the demonstration experiment, over 20,000 ebooks were downloaded of which 47% were from developing countries. While usage of mobile devices was 43.9%, lower than that of the usage of PCs (56.1%), 73% of the users utilized the EPUB format on mobile devices. Results also show that 34.3% of the learners used both EPUB-based and Web-based CHiLO books.

One of the reasons for comparatively high usage of PCs was the still high rate of PC ownership to mobile device ownership though it is said that mobile devices are spreading rapidly. Therefore, considering the fact that mobile device ownership will increase in developing countries, CHiLO has the potential to provide effective online education.

However, an issue which arose in the demonstration experiment was that learners could not fully enjoy the merits of EPUB3-based CHiLO Books. Despite the embedded videos meeting specifications of EPUB3, many existing e-book readers on EPUB3 did not support the embedded videos. The result was that the e-book readers did not work as expected with the embedded videos.

To address this problem, we will soon release a dedicated e-book reader (called CHiLO Reader) for CHiLO Books, to enhance their usability. The CHiLO Reader is compliant with EPUB3, embedded video, JavaScript, and JSON data. This will enable the development of all embedded-type CHiLO Books that contain assessment examinations and a digital badge-issuing feature. It will be possible to enjoy the learning activities without an internet connection, such as viewing a video lecture, which then results in earning a badge. The CHiLO Reader also has the feature of recording the student's learning history (outcomes, scores, tracking, and others) in absence of connecting networks. Once it is connected to the internet, records are sent to the Learning Record Storage.

To use CHiLO in a restricted network environment is another challenge. We attempted to implement MANET into the CHiLO Reader. Thus, each learner of the CHiLO Reader can build an ad-hoc network, with each device having the potential to route data to another device in a mesh network.

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