OER in the Mobile Era: Content Repositories' Features for Mobile Devices and Future Trends

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Tags

repository, open educational resources, learning object, ubiquitous learning, mobile learning

Learning objects and *open contents* have been named in the Horizon reports from 2004 and 2010 respectively, predicting to have an impact in the short term due to the current trend of offering open content for free on the Web. OER repositories should adapt their features so their contents can be accessed from mobile devices. This paper summarizes recent trends in the creation, publication, discovery, acquisition, access, use and re-use of learning objects on mobile devices based on a literature review on research done from 2007 to 2012. From the content providers side, we present the results obtained from a survey performed on 23 educational repository owners prompting them to answer about their current and expected support on mobile devices. From the content user side, we identify features provided by the main OER repositories. Finally, we introduce future trends and our next contributions.

1. Introduction

In 2004 *learning objects* (LOs) have been named in the Horizon report, as one of the relevant technology trends (Johnson & Laurence, 2004). This technology appears in the Horizon report from 2010 (Johnson et al. 2010) as *open content*, predicting to have an impact in the short term due to the current trend of offering open content for free on the Web.

Open Educational Resources (OERs) not only comprise LOs, course materials, content modules and collections; likewise, include tools for creating, delivering, using and improving educational contents. The term OER was first used at a UNESCO conference in 2002[1]. Previously, Koper (2001) had proposed a meta-language that allows to codify (see Figure 1) the pedagogic values of learning objects as units-of-study, associating each element of content with information describing its instructional strategy. Chitwood & Bunnow (2005) defined LOs with five characteristics: small units of learning, typically ranging from 2 minutes to 15 minutes; self-contained, each learning object can be taken independently; reusable, a single learning object may be used in multiple contexts for multiple purposes; can be aggregated, learning objects can be grouped into larger collections of content, including traditional course structures;

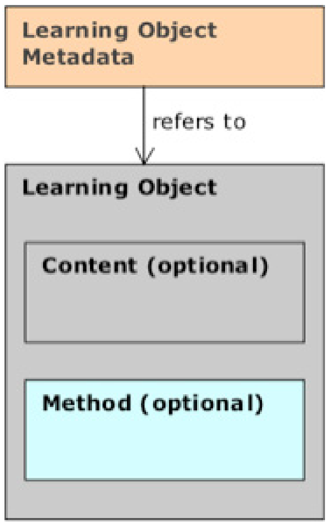

Figure 1: EA common view of learning objects and its metadata. (Koper; 2001)

1 UNESCO Conference "Forum on the Impact of Open Courseware for Higher Education in Developing Countries", July 2002

are tagged with metadata, every learning object has descriptive information allowing it to be easily found by a search.

The advent of mobile technologies and the boom happened in 2007 with the birth of smartphones have boosted new ways of interaction. These mobile devices are equipped with capabilities (text editor, audio recorder, video recorder, sensors, internet access, apps, etc.) that facilitate enormously the possibilities to create, publish, discover, acquire, access, use and re-use of educational resources. By mobile device we do not only refer to cell phones, but also to tablets, MP3s, MP4s, game consoles and portable computers. Mobile devices play an important role in lifelong learning. Lifelong learning includes a variety of different educational scenarios and contexts in which learners operate (Tabuenca, Ternier & Specht; 2012) and mobile devices should be a ubiquitous access point to OERs stored in content repositories.

In the last years, the usage of mobile devices has grown in many application fields of the education. Contents are mobile and LOs have evolved to Mobile Learning Objects (MLOs). OERs are stored in repositories facilitating efficient search, retrieval and re-use among different educational communities. There are existing works aiming to provide personalized learning contents based on variables supplied by our mobile devices. The work from Su, Tseng, Lin & Chen (2011) summarizes research on adapted mobile content delivery based on mobile capabilities, learners' preferences, and network conditions.

OER repositories must do their best to provide suitable mobile contents. So far no clear work was found synthesizing how OER repositories are adapting to the mobile learning paradigm and the facilities they are providing. The contribution of this paper is giving an answer to these questions: which is the position of OER repositories after all these changes?; how are OER repositories and mobile devices coexisting?; did content repositories take the speed train of mobile computing?; how do OER owners adapt their portals to the mobile era? .

This paper is organized in six sections. Section two summarizes recent trends in the creation, publication, discovery, acquisition, access, use and re-use of learning objects on mobile devices based on a literature review on research trends from 2007 to 2012. The third section presents the results obtained from a survey performed on 23 educational repository owners prompting them to answer about their current and expected support on mobile devices. Section four analyzes what concrete mobile features are providing the main OER repositories. Section five presents discussion and conclusions. Finally we describe our future work.

2. Literature review on learning objects for mobile devices

This study investigates research trends on the creation, publication, discovery, acquisition, access, and use of mobile OERs.

2.1 Method

Five major digital libraries were selected to find relevant papers in the usage of mobile devices to access OERs repositories. These libraries are ACM, IEEE, Science Direct, Springerlink and Wiley. We searched the listed libraries constructing search-strings that follow the pattern: all papers published after 2006 that contain ("Mobile" AND "learning" AND "object" AND "repository" AND "content" AND "education") in their full-text AND (contain ("mobile") in their keywords OR contain ("mobile") in the title).

This query reported the following number of items: 21 in ACM; 165 in IEEE; 26 in ScienceDirect; 36 in Springerlink; 12 in Wiley. For each of these libraries, results were ordered by relevance and the 20 first elements were extracted. The resulting list of 92 papers was manually checked.

2.2 Results

2.2.1 Creation of contents

Nowadays, mobile devices are equipped with capabilities that facilitate the creation of learning contents. These devices are in the hands of any person willing to record audio, record video or compose a text. Likewise, the quality of the audio and video reproducers, and the increase of the size of the screens to display text, has augmented considerably the degree of excellence for consuming contents with respect to the pre-smartphone era. The exploratory study by Churchill & Hedberg (2008) describes considerations to take into account when designing LOs for small-screen handheld devices.

2.2.2 Publication of contents

Standards are being reformulated to adapt the publication of LOs in content repositories. Tagging resources with meta-data is essential to guarantee their reusability. The need for analyzing the issues that raise the inclusion and use of metadata in the learning objects delivered to mobile devices was already pinpointed by De Marcos, Hilera, Gutiérrez, Pagés & Martínez (2006) as an investigation line pending to develop. For example, the IEEE LOM specification does not directly support the description of educational resources in terms of their relevance to language learning and mobile-delivery related characteristics as claimed by Zervas & Sampson. (2010). This challenge is absolutely necessary for facilitating teachers and trainers in their search, acquisition, (re)-use and share of appropriate educational resources for language learning activities and courses.

2.2.3 Content allocation

This literature review has resulted in the following different ways for learning contents to be allocated by mobile devices, namely, GPS, compass, Wi-Fi, RFID, infrared, barcode, Bluetooth, text recognition and image recognition. Moreover, 3D virtual environments supported by mobile devices have been implemented in order to facilitate learners to explore and search LOs within OER repositories.

The mobile phone camera has been used with the aim to recognize real images of off-line contents, allowing rapidly gain access to a large repository of multimedia information (Han, Yang & Jung; 2007). Moreover, augmented reality in textbooks was implemented in Santana-Mancilla, García-Ruiz, Acosta-Diaz & Juárez, (2012) allowing secondary school students access to additional educational contents related to their textbooks. This system recognizes the images printed in the book as part of regular taught topics and shows multimedia contents that complement the topics covered in the book. Similar but recognizing a marker was the experiment by Chao & Chen (2009). Markers are printed text identifiers that can be easily read and tracked by a computer.

Excursions of art and museum are good examples of content delivery based on the parameters supplied by mobile devices. Mobile guides delivering contextualized audio, video and text are reviewed in recent work from Emmanouilidis et al. (2012). This work claims that the current trend is to gradually abandon some of the older localization technologies such as Wi-Fi, infrared and manual user position input. The near ubiquity of GPS receivers in mobile devices makes this technology extremely popular, nevertheless, they are high battery consumer. Oppermann & Specht (1999) performed the first relevant experiment using infrared for location identification and wireless LAN for data transmission to and from the server in a museum. Audio contents where delivered from a private repository.

Other localization technologies, such as Radio Frequency IDentification (RFID) and 2D barcodes, have become more popular due to better device support. Chen, Teng & Lee (2010) implement an augmented reality scenario enriching textbooks with multimedia content stored in a repository. These contents were addressed reading Quick Response (QR) codes printed next to the text to enrich. Chen & Huang (2012), Choi & Moon (2008) and Huang, Chang & Sandnes (2008) present examples of contextualized content delivery indexed by RFIDs.

Near Field Communication (NFC) is an extension to RFID technology. RFID is capable of accepting and transmitting beyond a few meters while NFC is restricted to within four inches. There is a trend[2] in mobile phones to be equipped with NFC. This type of communication has been used with the purpose of accessing contents. A recent experiment implemented a scenario in which a user carrying her mobile phone in a fieldtrip excursion could touch (with her mobile phone) objects augmented with NFC tags. When these tags were read, the path where the content is stored into the mobile phone appears on the screen. When pressing select, the corresponding audio, video or image file is reproduced. When a tag is touched, the register of the activity is always updated with the information of the tag and the time it was accessed. The teachers upload all the contents into a public repository so that all the students can have access to them (Pérez-Sanagustín, Ramirez-Gonzalez, Hernández-Leo, Muñoz-Organero, Santos, Blat & Delgado-Kloos; 2012).

Mobile accelerometer gestures are able to control a 3D car gaming metaphor to navigate learning resources in repositories (see figure 2). This implementation was created by Rahman & El Saddik (2011) who included an additional functionality to access, play, and store the learning objects for later browsing through the mobile interface.

Web browsers keep being the main access point to a repository. MERLOT is an example of portal based repository adapting the search functionality depending on the type of mobile platform aimed to use the content. Siadaty, Eap, Jovanovic, Gasevic, Torniai & Hatala (2008) propose the m-LOCO framework for contextualized mobile content delivery making use of different repositories: the repository of learning objects includes information about the content structure (e.g., audio, video, text) and educational content types (e.g., example, overview or tutorial) of the learning content; the delivery media repository contains data

2 300 million smartphones equipped with NFC technology by 2014. http://www.efma.com/index.php/content/top_stories/detail/EN/1/82/1-G2F98

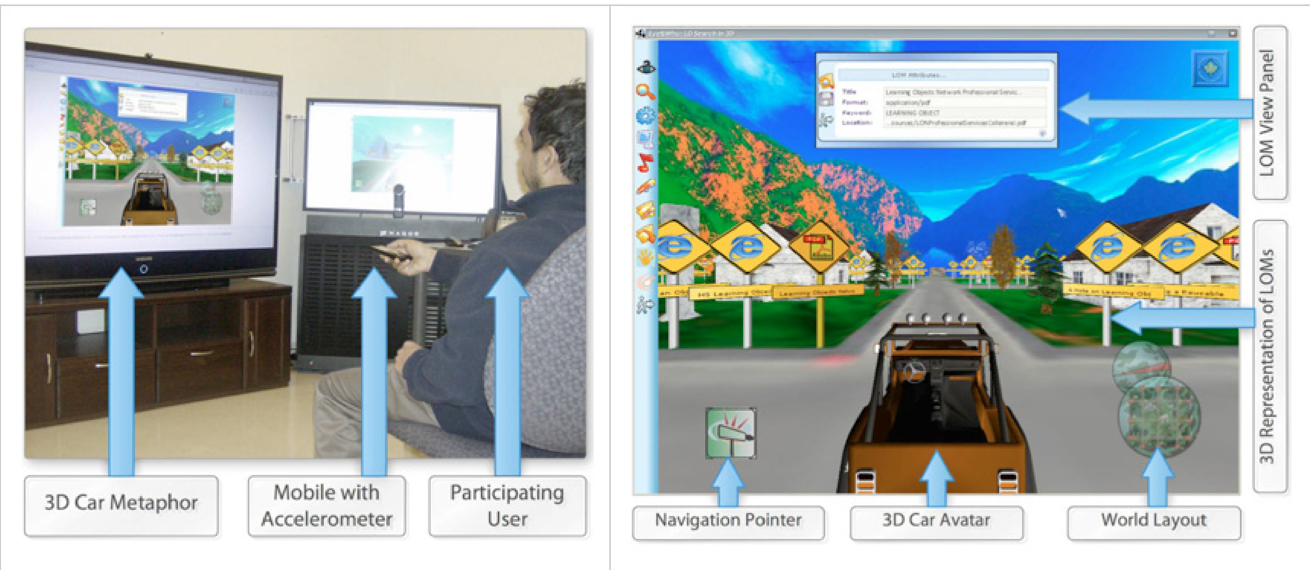

Figure 2: Mobile retrieval and navigation of LOs using a 3D Car Metaphor. Rahman & El Saddik (2011)

about specifications and features of different available delivery media (e.g., mobile devices and PDAs); the context repository is used to perform further analysis or reasoning (e.g., every time a learner selects a learning object from the learning object repository, the related contextual data would be gathered and stored in the repository).

2.2.4 Standards for content packaging, delivery and sequencing

IMS Learning Design[3] and the SCORM[4] are the most important standard models for interoperability and reusability in eLearning. This review has arisen the following solutions making use of these standards in mobile devices:

The *Pocket SCORM* is a SCORM reader on mobile devices with access to an Learning Management System (LMS) server and a SCORM repository. This tool was first released in June 2004 for Windows Mobile. The authors of this paper did not find further work on this tool (Chang, Chang, Sie, Lin, Huang, Shih & Jin; 2004).

The *SMILE PDA* is an open source software implementation for executing IMS Learning Design activities via mobile devices. In comparison to existing IMS Learning Design Players, such as, Coppercore[5] and Reload Player[6], the SMILE PDA does not need to be connected to the internet during the entire execution time; saves battery since it has a lower computational power, extra memory and storage capacity from the mobile device in use; it has been specially designed for delivery through mobile user interfaces; the educational content can be automatically adjusted to the size of the display of the device used (Sampson & Zervas; 2008). Read the "Mobile2Learn" framework in the 4th section for further details.

The *eXact*[7] mobile is a commercial solution for standard-based, single-source development, management, delivery and tracking of multimedia training. These are the main features: tracking and synching even when offline; standard-based, authoring, delivery and tracking; content is created according to recognized standards (e.g. SCORM) for a future-proof guarantee that will work with all LMSs; supported for Android, iPhone, iPod and Blackberry.

The *PLCAM* delivers SCORM MLOs based on learners' preferences, hardware profile and "satisfaction degree" of these contents in previous usages (Su et al. 2011).

3 IMS-LD. IMS Learning Design: http://www.imsglobal.org/learningdesign/index.html

4 SCORM. Shareable Content Object Reference Model: http://www.adlnet.gov/capabilities/scorm

5 CopperCore, The IMS Learning Design Engine. http://coppercore.sourceforge.net/

6 Reload Project, Reload IMS LD Player. http://www.reload.ac.uk/

7 eXact mobile http://www.exact-learning.com/en/products/learn-exact-suite/exact-mobile-solution-for-mobile-learning

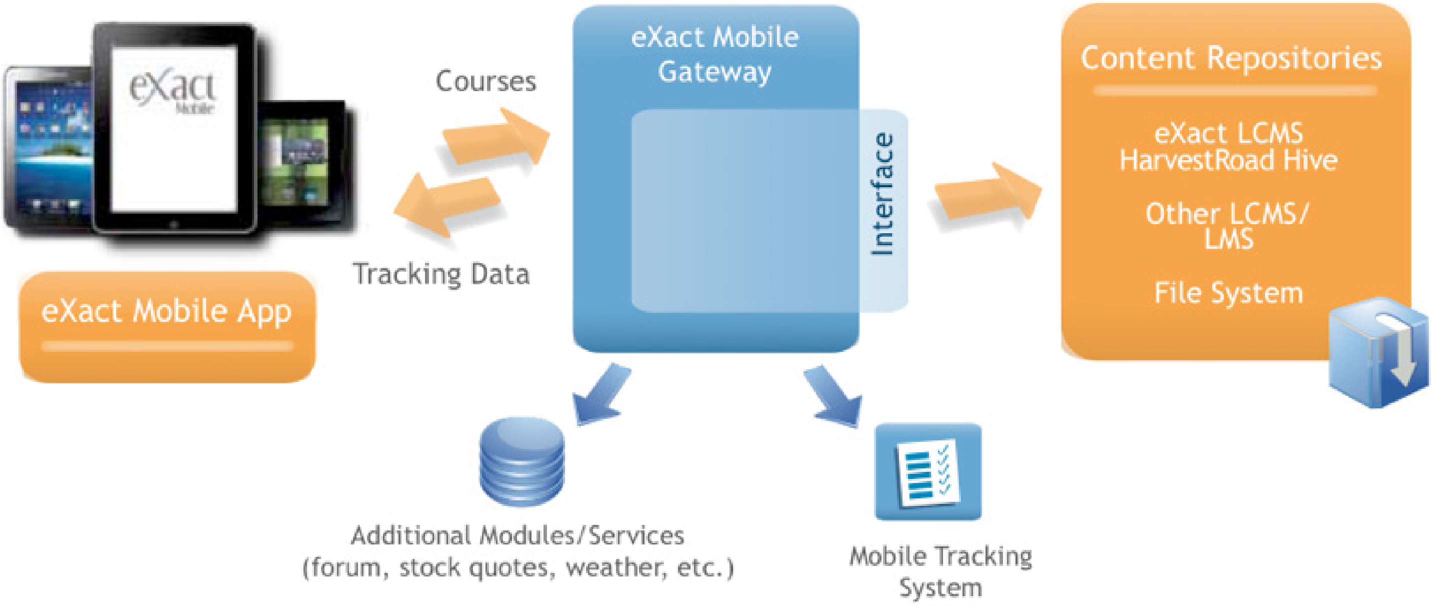

Figure 3: Architecture of eXact mobile

2.2.5 Architectures framing mobile content delivery

Figure 3 represents the architecture of eXact. This configuration is analogous to the previously described in De Marcos et al. (2006). The mobile gateway in the figure resembles the mobile LMS (mLMS) in the above-mentioned paper. This module is entrusted to manage all the aspects related with courses and participants. Its basic functionality covers the capability to serve the contents required by learners in order to serve them properly. A variation of this architecture is proposed in Castillo & Ayala (2008).

The service-based learning architecture was recently introduced aiming to provide educational institutions the flexibility of adding and re-using services inside the already existing platforms. Hence, many basic services and resources must not be developed again, reducing considerably the complexity in the design of new educational environments, and focusing the attention on the eLearning platform as center of the on-line education process as repository of both resources and services (Martín, Sancristobal & Castro, 2009). In their review of existent solutions, they conclude suggesting an architecture (figure 4) where the LMS services were transferred to mobile devices through the creation of a series of Web-Services that outsource these resources offering on mobile devices in an appropriate manner.

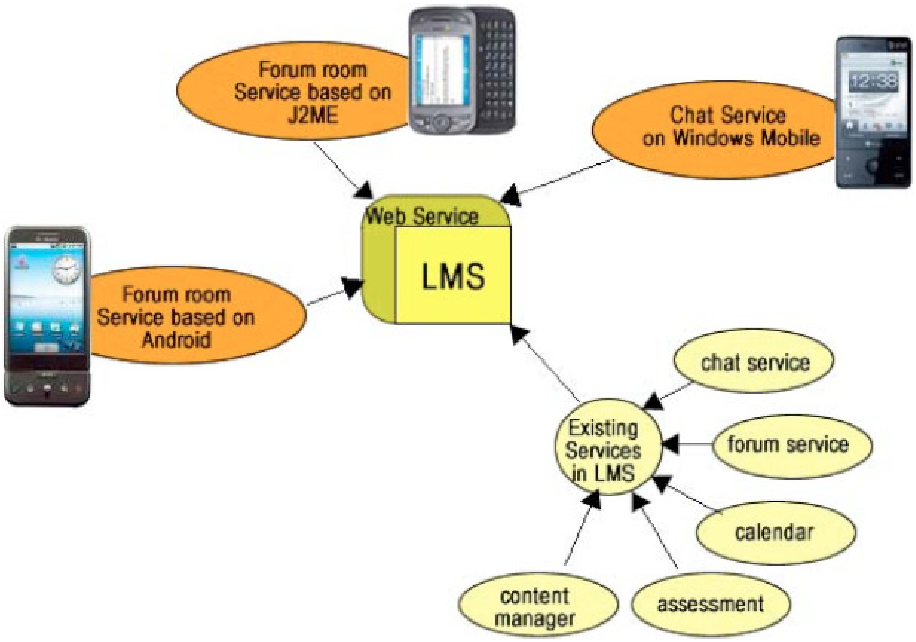

Figure 4: Integration of LMS services in different mobile devices. (Martín, Sancristobal, & Castro; 2009)

2.2.6 Content repositories and ubiquitous computing

Tagging physical objects (books, pictures, sculptures, etc.) with QR or RFID to enrich

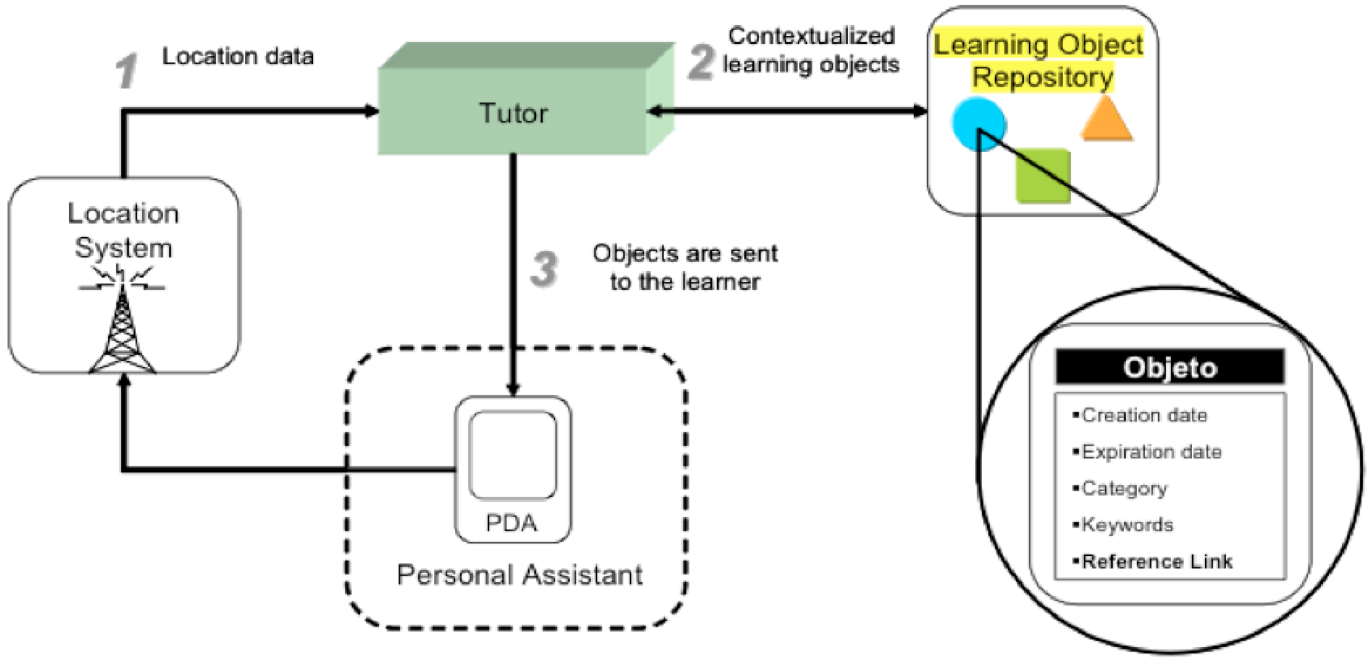

Figure 5: LOs management in LOCAL (*LOcation and Context Aware Learning*) by Hahn, Barbosa & Geyer. (2007)

them with multimedia content has resulted in successful experiments where the resource repository keeps content-related materials that were not originally provided in the physical object: texts (Chen et al. 2010; Chao & Chen 2009); images (Han et al. 2007; Santana-Mancilla et al. 2012); physical objects (Pérez-Sanagustín et al. 2012). These learning materials can be predesigned by the instructor or be obtained freely from the Internet.

The review has arisen different examples of ubiquitous computing scenarios broadcasting context based learning contents to mobile devices. Figure 5 shows how LOs are delivered to learners depending on the physical location of the learner and their progress status completing the tasks (Hahn, Barbosa & Geyer 2007; Barbosa, Hahn & Barbosa 2008). Recently, Rahman & El Saddik (2012) designed a prototype that makes use of accelerometer and infrared to launch LOs in different displays by pointing at them with the mobile device. This approach represents a case of use where the mobile device is used as a hub to distribute where contents should be displayed (see figure 6).

Figure 6: Learner distributing contents for delivery on different displays. Rahman & El Saddik (2012)

3. A survey to OER repository owners on mobile usage

This section presents the results of a survey performed on 23 content repositories, partners of the Open Discovery Space[8] European project, hosting more than 1,583,000 resources. This is an approximation since some of the contents could be overlapped in more than one repository. The aim of this survey is to gain insights into the way content repositories provide access to different mobile devices. OER repository owners are asked if they are aware of the already existent APIs. Moreover, they are prompted to answer about their willingness to provide new features and which ones do they appreciate more beneficial.

3.1 Participants

Table1 lists educational repositories, collections and federations participating in this survey.

OER repository	Scale & Scope
ARIADNE federation	International teachers & students
	~1,000,000 educational resources
	~ 55 federated repositories
Open Science Resources repository	European science teachers
	~1,200 content resources
eduTubeplus video library	European teachers & students
	~5,000 educational video resources
COSMOS repository	International science teachers
	~100,000 content resources
I2G Intergeo repository	European math teachers & students
	~3,500 educational resources
Key2Nature's Dryades repositories	European biology teachers & students
	~400 school projects
	~86,000 content resources
OpenScout federation	International teachers & students
	~ 53,000 educational resources
SIVECO's ASPECT repository	Romanian teachers
	~200 content packages with ~1600 learning objects in total
FUNecole® Educational Content Repository	European teachers & students
	> 1,500 educational resources
LaProf educational content repository	European language teachers & students
	~800 educational resources
Miksike's LeFo repository	Estonian, Lithuanian & Latvian teachers
	~50,000 educational resources

8 Open Discovery Space. A collaborative and multilingual open learning infrastructure designed to boost demand for Europe-wide eLearning Resources. http://www.opendiscoveryspace.eu/

OER repository	Scale & Scope
Bulgarian national educational repository	Bulgarian teachers & students
	~3,500 educational resources
Virtual Bulgaria educational portal repository	Bulgarian teachers, students, parents, public
	~7,000 multimedia resources
Znam.bg collection	Bulgarian teachers, students, parents, public
	~100,000 content resources
	~15,000 unique visitors per month
BMU collection of eLearning content (including Digiš school repository)	Serbian teachers & students
	~180 online courses
Croatian national school repository	Croatian teachers & students
	~2,700 educational resources
Greek national school repository	Greek teachers & students
	~thousands of educational resources expected to be aggregated
Bildung.at repository	Austrian teachers
	~500 educational resources
LMS.at repository	Austrian teachers
	~10,000 courses, including >100,000 learning resources
Ambjorn's Naeve math repository	Math teachers
	~300 of educational resources
Open Educational Resources Commons (OERCommons. org)	International teachers
	~70,000 educational resources

Table 1: OER repositories that participated in the survey

3.2 Methodology

This survey is aimed to collect information about the repository's accessibility via mobile devices, potential future apps and functionalities from the repository owner's point of view. Content owners received an email in which they were prompted to answer six questions related to mobile usage. Guidelines and examples of possible ways to fill in the requested information were included. The collected files were analyzed obtaining the following results.

3.3 Results

This section presents the outcome of the analysis performed on the input that was collected from the ODS partners; these are the repositories they represent.

1. Did you prepare your repository to be accessed with different mobile devices?

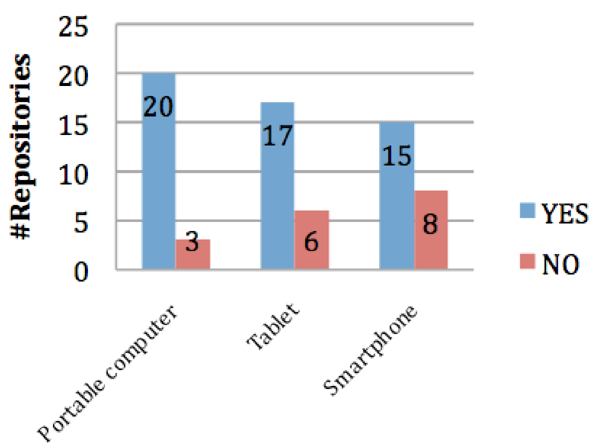

Figure 7: Being accessible by mobile devices

As shown in figure 7 the majority of the repositories (87%) can be accessed by portable laptops. Tablets are in the second place and they can access almost 74% of the repositories. Last but not least, more than 65% of the repositories are accessible with smartphones. In fact, more than half of the repositories can be accessible by all the mobile devices including portable laptops, tablets, and smartphones.

2. Did you consider providing an app to access the content in you repositories?

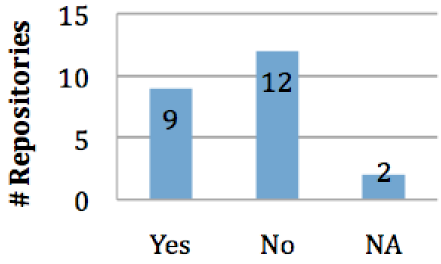

Figure 8: Providing an app

As shown in figure 8, nearly 40% of the repositories take into account providing an app to enable users accessing their content and the remaining repositories (52%) do not consider providing access through an app. We didn't receive any information from less than 8% of the repositories.

3. Do you know any suitable app for accessing content repositories and open content?

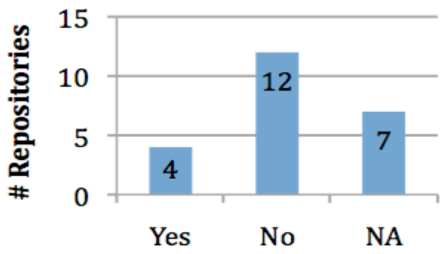

Figure 9: Suitable apps for repositories

Although most of the repositories think an app can increase the access rates to their repositories as shown in figure 9, only less than 18% of them know a suitable app to access content repositories and more than 50% of them have no idea what apps could be suitable for accessing content.

4. Do you think an app could increase the access rates to your repository?

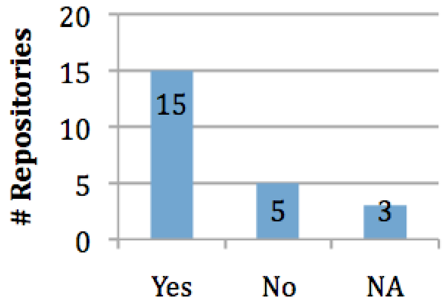

Figure 10: Think of using app to increase access rates

More than 63% of the repositories believe that the access rate to their repositories increases by providing an app to their repository. As shown in figure 10 while around 21% of them believes an app does not raise up their access rates.

5. Would you consider providing an application interface (API) to provide access to your repositories from other sites and apps?

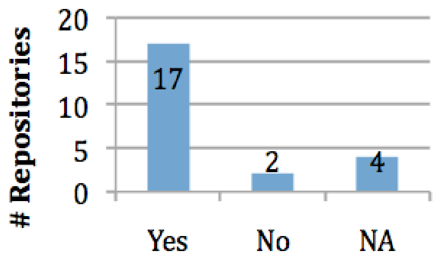

Figure 11: Consider providing an API

Figure 11 shows that almost 74% of the repositories tend to provide an application interface (API) to access their content from other apps and this outcome looks consistent with the results shown in figure 11. Only less than 9% of the repositories do not consider providing an API in order to access their repositories form the other apps.

6. What kind of functionality would be beneficial state of the art access to content repositories?

As shown in figure 12, in average 60% of the repositories found *ranking of the content, social collaboration*, and *cloud storage* as the most beneficial functionalities to provide mobile access. Furthermore, more than 30% of the repositories agree that the following functionalities are beneficial to provide state-of-the-art access to content repositories: location-based services,

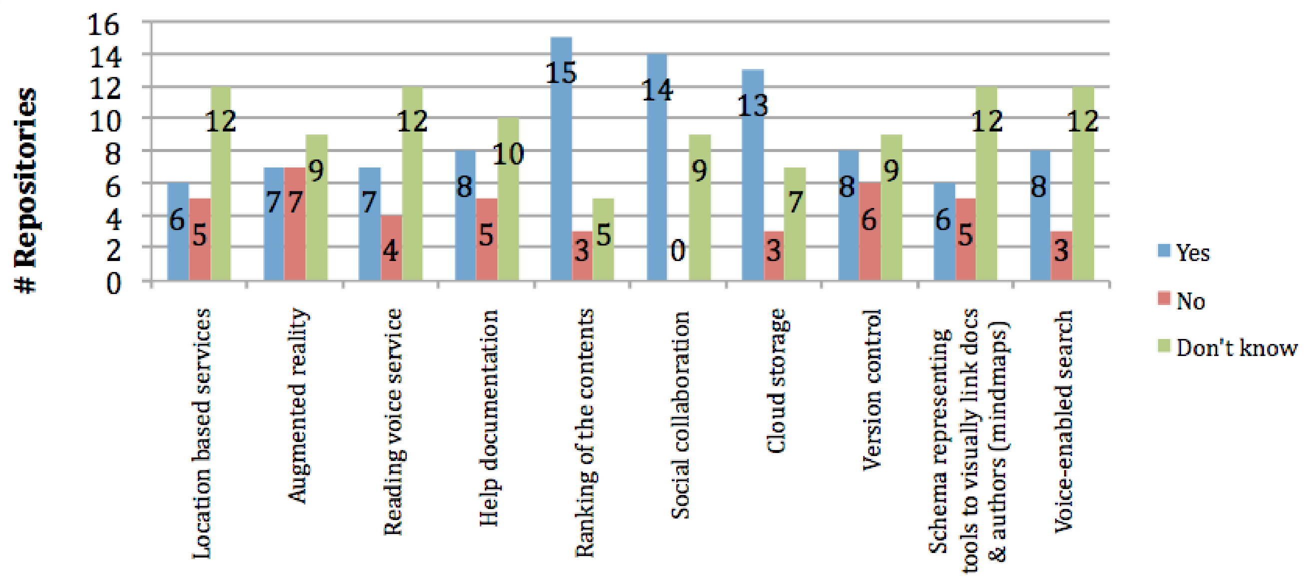

Figure 12: Suitable functionality to provide access to content repositories

augmented reality, reading voice services, help documentation, version control, schema representing tools to visually link docs and authors, voice-enabled search.

4. What mobile features are providing the main OER repositories

This section analyzes what concrete features are providing the main OER repositories for mobile learning. We have selected relevant OER repositories cited in the literature review having some initiative on mobile support. Moreover, we review relevant *referratories* that were excluded in the previous section. By referratory we mean a repository that only manages metadata from (Ternier, Massart, Totsching, Klerkx & Duval, 2010). The method to analyze them was by browsing their sites and the main app markets in Internet.

OpenScout

OpenScout[9] was launched in 2012. This portal provides free online management to OERs, that is search, visualize, use, share and publish. The OpenScout supply users with an interface to

9 OpenScout. Skill-based scouting of open managment content. http://learn.openscout.net/

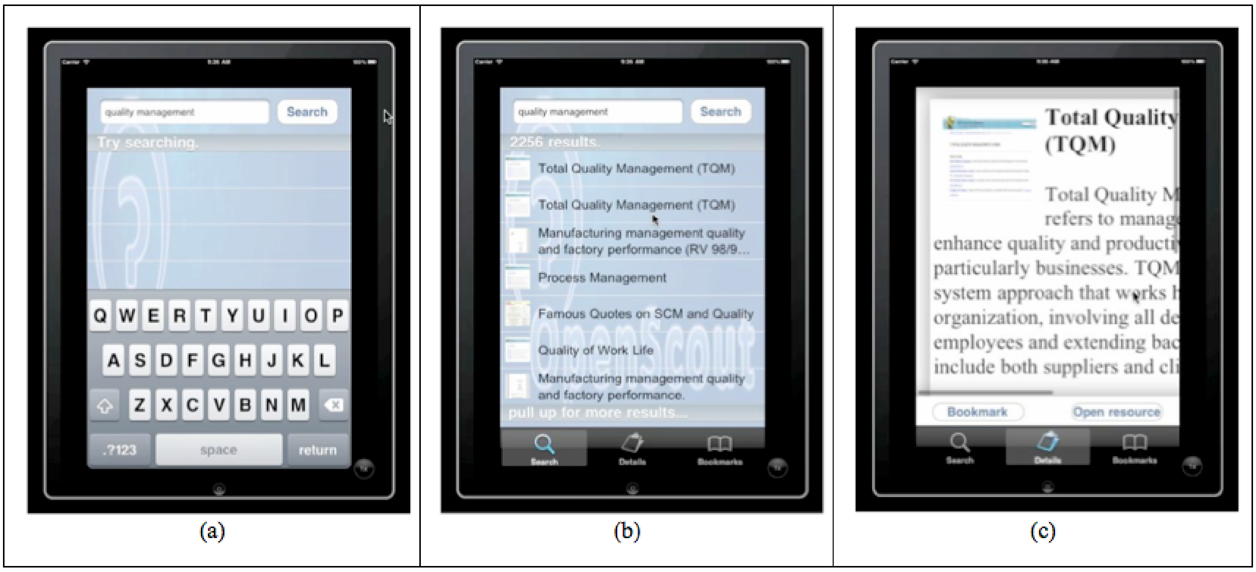

Figure 13: OpenScout app. (a) Keyword search; (b) Search results; (c) Zoomable Item Details Interface

start a keyword-based search, filter search results, include competence search criteria, or add social metadata like tags, comments or ratings.

Regarding the features supporting mobile devices, Parodi, Vannucci, Schwertel, Weber, Kawase & Niemann (2012) describe the OpenScout app for iOS. The app provides a starting-point keyword search (Figure 13a.). The query is then issued to the OpenScout repository and search results are displayed within the app interface (Figure 13b.). The search results are sorted by relevance. Within the app, users are able to see details of the resources (Figure 13c.), bookmark and open them in the browser visualization. Bookmarks are saved locally in the users' device facilitating the organization and collection of interesting items.

Mobile2Learn

Mobile2Learn[10] aims to improve language-learning instruction by expanding the resources for teaching and learning in vocational education training. This portal intends to promote access to mobile-supported training services for the provision of on-demand lifelong language learning, beyond time and place restrictions. Mobile2Learn provides a stand-alone application (MW-TELL) that can be installed in a PDA or smartphone device and facilitates the delivery of mobile training courses. The main functionalities of *MW-TELL Courses PDA and Smartphones Player* include: delivery of mobile training courses packages for English language learning; support of multiples roles, such as individual learners and tutors; rendering of HTML–based content and flash files conformant with the IMS Learning Design v1.0 Level A specification and IMS Content Packaging v1.1.4 specification.

Sampson & Zervas (2012) present an implementation of the Mobile2Learn framework for English language-learning concluding the following indications: existing Mobile-Assisted Lifelong Language Learning (MALL) resources can be re-used within different MALL courses, while retaining their open access by different platforms and systems; existing MALL course templates can be re-used within different MALL courses addressing teaching of a specific language. Moreover, MW-TELL has been experimented in Romero, Zarraonandia, Aedo & Díaz (2010).

Figure 14 represents how resources can be imported (a). MW-TELL identifies related resources (b) and tracks the progress on the activities to be performed within the Learning Object (c).

10 Mobile2Learn. Mobile and Wireless Technologies for technology enhanced learning. http://www.mobile2learn.eu/

(a) Import package | (b) Related resources | (c) Track activities performed

Figure 14: MW-TELL mobile app from Mobile2Learn

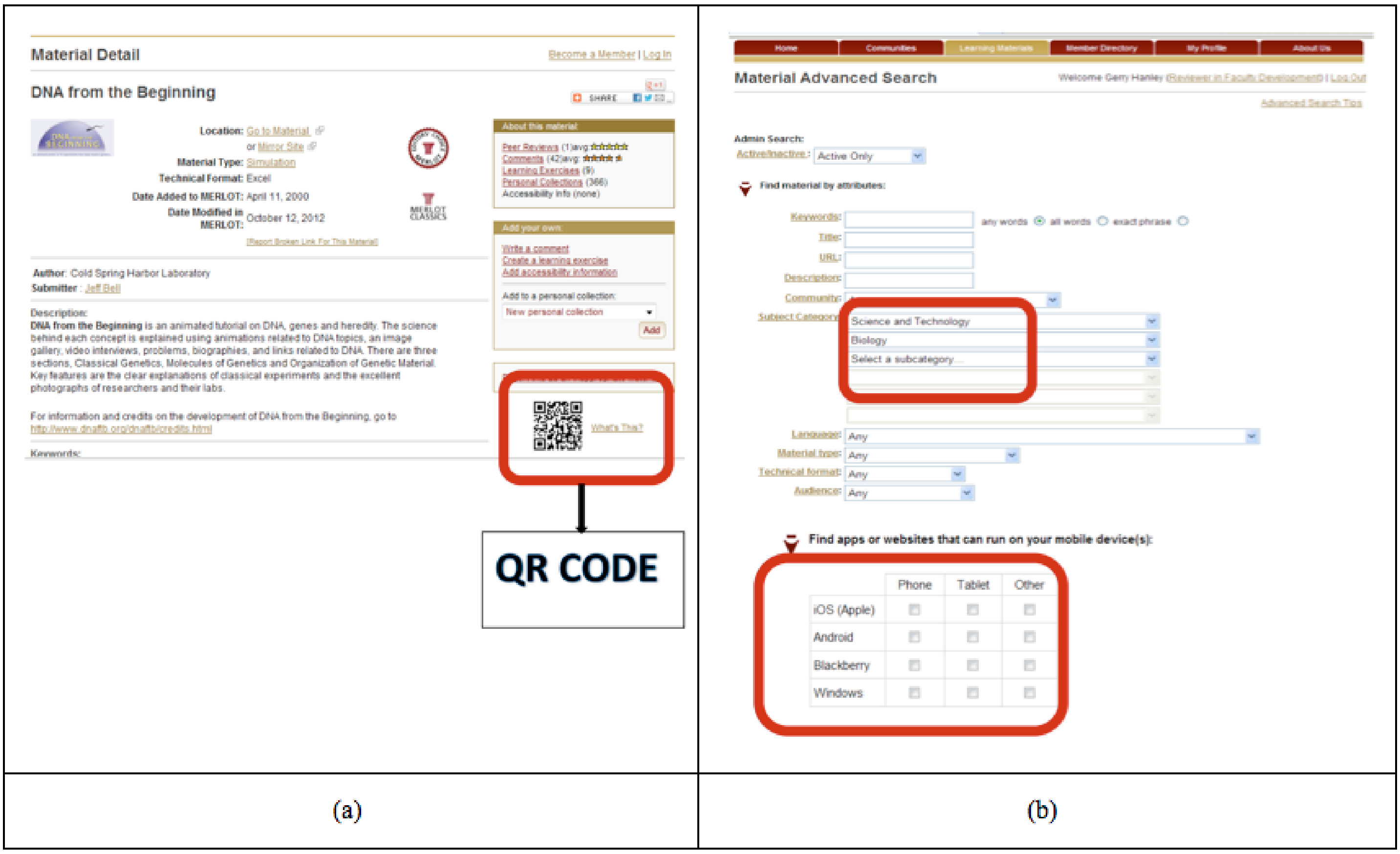

Figure 15: MERLOT. Mobile features – (a) QR code allocation – (b) Advanced search by type of delivery platform and subject. http://www.merlot.org/merlot/advSearchMaterials.htm

MERLOT

MERLOT[11] is a free and open online community of resources designed primarily for faculty, staff and students of higher education from around the world to share their learning materials and pedagogy.

MERLOT provides different capabilities for mobile support. The free MERLOT OER Search app for iOS and Android-based mobile devices searches the MERLOT database for open educational materials. MERLOT OER Search app enables mobile users to retrieve detailed, discipline-based information on thousands of Open Courses, Open Texts, and Open Journal articles directly from MERLOT's internationally renowned digital library. Retrieved information includes all the comments, ratings, related learning exercises, and peer review information stored in MERLOT's digital library, with links directly to the learning materials in the hit list. It is possible to share findings with colleagues via mobile device. Moreover, MERLOT maintains and index to mobile app with educational purposes.

All materials in MERLOT have a QR code (See Figure 15 a.). Once a learning material is found, it is possible to share it by scanning the QR code and the mobile device would show the website.

MERLOT provides an advanced search (Figure 15 b.) for materials designed for mobile devices including the criteria *"Type of delivery platform"* to the information (metadata on smartphones, tablets, LMS's). Moreover, MERLOT guides through a step-by-step process for creating and cataloging new mobile apps useful for teaching and learning.

OpenCourseWare

The OpenCourseWare (OCW) movement started in Tübingen (Germany) but it was finally launched at Massachusetts Institute of Technology (MIT). OCW MIT[12] is an open, free, web-based

11 Merlot. Multimedia Educational Resource for Learning and OnlineTeaching. http://mobile.merlot.org/

12 OpenCourseWare. Massachussets Institute of Technology. http://ocw.mit.edu/

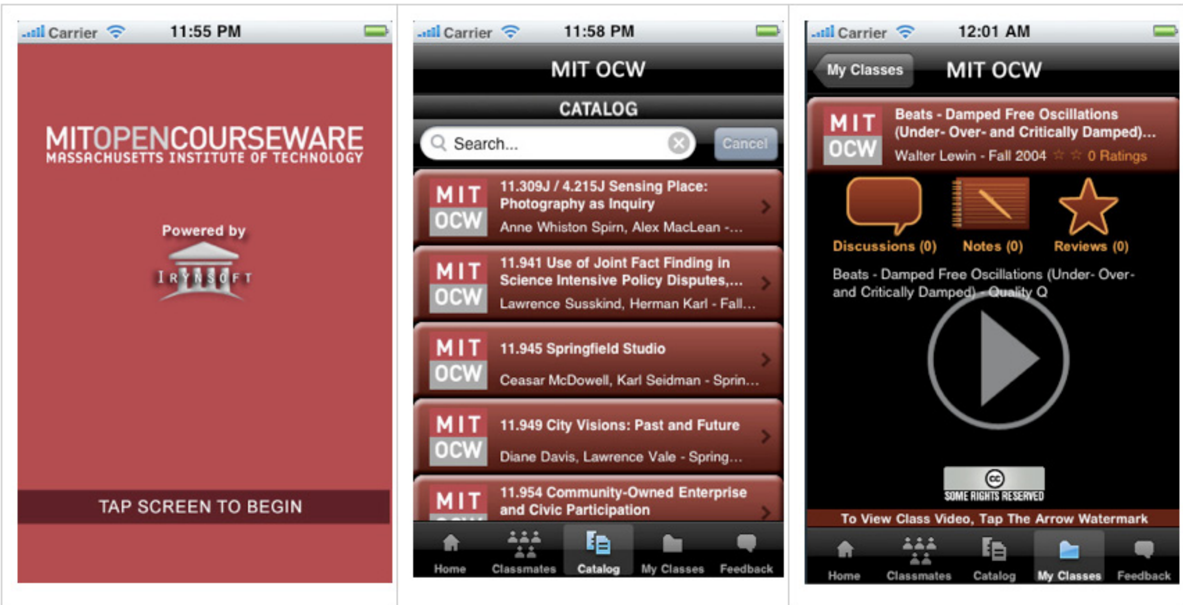

Figure 16: MIT OpenCourseWare LectureHall By Irynsoft

publication of all courses and contents taught at MIT. This initiative has been widely extended to multiple universities around the world.

MIT OCW released an iPhone app in February 2011 (Figure 16) allowing to access OCW videos stored in iTunes. Its social learning experience makes this app different from others. This app includes a virtual space called "classmates" where students can discuss with colleagues.

Khan Academy

Khan Academy's[13] website supplies a free online collection of more than 3,500 micro lectures via video tutorials stored on YouTube covering a broad range of educational topics. Khan Academy has a higher rate of videos viewed in comparison to MIT's OCW[14].

The Kahn Academy launched an official app both for Android and iPhone (Figure 17 a. January 2011) and iPad app (March 2012). Its main functionality is providing access to videos. There are also unofficial viewer apps that let import the Facebook profile (Figure 17 b.c.).

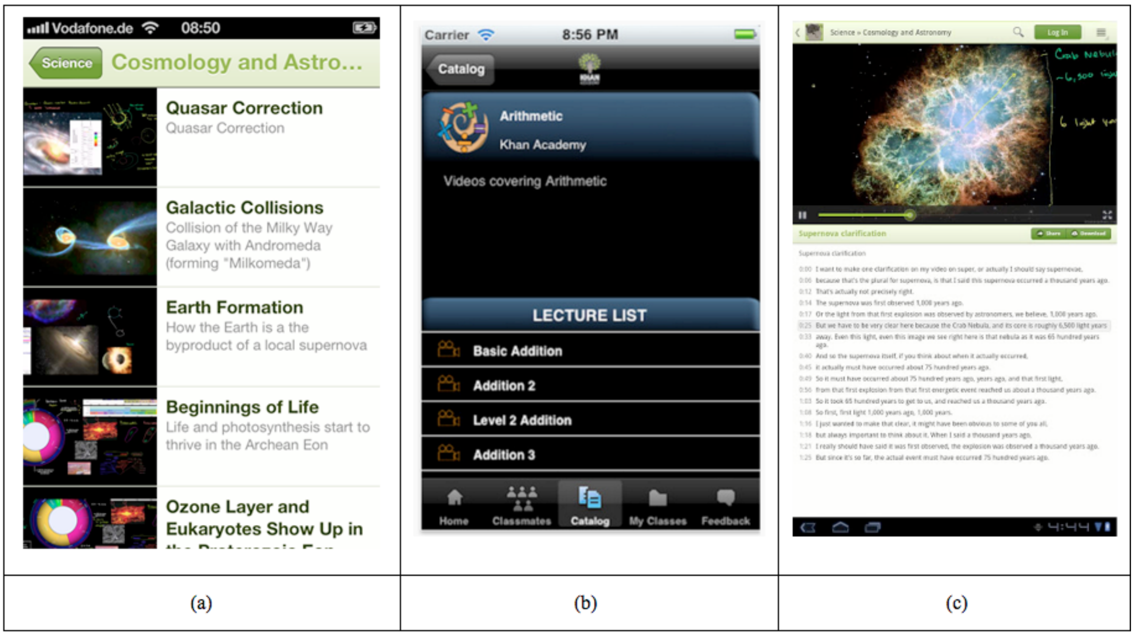

Figure 17: Mobile Apps for Khan academy – (a) Khan official iOS app – (b) Unofficial Khan Academy app for iPhone by Irynasoft – (c) Unofficial Khan Academy app viewer for Android

5. Discussion and conclusions

This study has revealed the following findings:

Mobile devices offer new ways to access contents in learning repositories. This work has brought to light experiments using GPS, compass, Wi-Fi, RFID, NFC, infrared, QR code, Bluetooth, text recognition, image recognition and accelerometer features to identify and access contents stored in learning repositories.

13 Khan Academy. http://www.khanacademy.org/

14 Solomon, Ethan A. http://tech.mit.edu/V131/N57/khan.html. "Sal Khan is Commencement speaker"

These features have been put into practice in different experiments (Chen et al. 2010; Chao & Chen 2009; Han et al. 2007; Santana-Mancilla et al. 2012; Pérez-Sanagustín et al. 2012; Hahn et al. 2007; Barbosa et al. 2008; Rahman & El Saddik 2012) with successful results. From the ubiquitous learning paradigm, this study reveals new cues to augment physical spaces (books, museums, etc.) with digital learning contents supplied on mobile devices and extracted from content repositories.

Easy to create and consume mobile contents are those whose unit of construction is text, audio or video. Smartphones and tablets are equipped from scratch with tools that facilitate easy creation and consumption of this type of materials, this means, no special app or feature needs to be installed. Most of the cases of study carried out in the last years retrieve this format of materials to be delivered in different types mobile devices.. Adapting existing web-based eLearning materials to the mobile learning setting has been experimented by Yang M-C. (2007) who exposes a pilot framework for aggregating and editing mobile learning materials from the existing web-based eLearning materials. Technologies like HTML5 make easier the integration of audio, video, and texts in mobile platforms.

Adapting more complex contents like LOs to become MLOs is hard to sustain in long terms and the speed train of mobile technology goes very fast. The original LOs were created for eLearning platforms and some of their features are missed when moved to a mobile context (screen size, content sequencing, etc.). As discussed in the experiment adapting LOs to MLOs from (Bradley, Haynes, Cook, Boyle & Smith (2009) *"LOs were developed to tackle a series of pedagogical challenges, such as facilitating learner engagement, and aiding students in dealing with problems of abstraction and complexity. These learning objects use a number of constructivist principles provided by rich interactive visualizations or learner controlled pacing"*. These principles are not always applicable on mobile devices. Even though no "killer app" adapting LOs to MLOs was found, this review highlights apps sequencing learning contents (e.g. eXact and MW-TELL mobile app). These apps follow the standards (IMS, SCORM) and are closely attached to their frameworks.

From the repository owners' point of view, the results of the survey indicate that the majority of the content repositories are accessible by different mobile devices. This means they are accessible using a web browser. Features like and advanced content search by type of mobile providing an app to enable their users accessing their content are not considered by the majority of them. These results illustrate how much the repositories are in a significant need of being and staying informed about the state-of-the-art of mobile applications since the majority of them have no idea of what app could be suitable for accessing content. In fact, repositories believe that proving an app would increase the access rate to their repositories. This study highlights functionalities that repositories could include in future apps. Mobile apps have become increasingly popular across the users and the repositories need to react on this new user demand. One interesting finding is that the big majority of the repositories tend to provide an application interface. Web-service architectures like (Martín et al. 2009) facilitate this extension and should be standardized in the way to provide a common interface to the different type of mobile devices.

6. Future work

In future work, we will implement an augmented reality tool based on ARLearn (Ternier, Klemke, Kalz, Van Ulzen & Specht. 2012) that will provide capabilities to retrieve learning contents addressed by NFC and QR indexes. This software will also be able to launch learning contents retrieved from repositories, to be presented and consumed in different channels and physical spaces. The purpose of this work is to make the best use of learning resources that are available to lifelong learners, to give them technological support across physical spaces, switching between learning task, and making use of smart objects embedded in daily activities.

Acknowledgments

The authors would like to thank The Netherlands Laboratory for Lifelong Learning (NELLL) for their support in this research, and the ODS project for their contribution in this paper.

References

Barbosa, J., Hahn, S.R.R. & Barbosa, D. (2008). LOCAL: a Model Geared Towards Ubiquitous Learning. Proceedings of the 39th SIGCSE technical symposium on Computer science education, 432-436

Bradley, C., Haynes, R., Cook, J., Boyle, T. & Smith, C. (2009). Design and Development of Multimedia Learning Objects for Mobile Phones. Edited by Mohamed Ally. Mobile Learning Transforming the Delivery of Education and Training. Published by AU Press, Athabasca University. 157-181

Castillo, S. & Ayala, G. (2008). ARMOLEO: An architecture for Mobile Learning Objects. 18th International Conference on Electronics, Communications and Computers

Chang H-P., Chang W-C., Sie, Y-L., Lin, N.H. Huang, C-H, Shih, T.K. & Jin Q. (2004). Ubiquitous Learning on Pocket SCORM. Springer Berlin / Heidelberg. Volume 3823/2005. Embedded and Ubiquitous Computing

Chao, P-Y. & Chen, G-D. (2009). Augmenting paper-based learning with mobile phones. Interacting with Computers 21. 173–185

Chen, C-C., Huang, T-C. (2012). Learning in a u-Museum: Developing a context-aware ubiquitous learning environment. Computers & Education 59. 873–883

Chen, N-S., Teng, D. C-E., Lee C-H. (2010). Augmenting Paper-based Reading Activities with Mobile Technology to Enhance Reading Comprehension. 6th IEEE International Conference on Wireless, Mobile, and Ubiquitous Technologies in Education

Chitwood, K. & Bunnow, D. (2005). Learning Objects: Resources for learning. The Wisconsin Online Resource Center Digital Library. 18th Annual Conference on Distance Teaching and Learning

Choi, J., Moon, J. (2008). MyGuide: a mobile context-aware exhibit guide system. Computational Science and Its Applications, ICCSA 348–59.

Churchill, D. & Hedberg, J. (2008). Learning object design considerations for small-screen handheld devices, Computers & Education 50, 881–893

De Marcos, L., Hilera, J.R., Gutiérrez, J.A., Pagés, C., Martínez J.J. (2006). Implementing Learning Objects Repositories for Mobile Devices. http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-208/paper04.pdf. Retrieved at 2012-11-04

Emmanouilidis C., *et al.* (2012) Mobile guides: Taxonomy of architectures, context awareness, technologies and applications. Journal of Network and Computer Applications, http://dx.doi.org/10.1016/j.jnca.2012.04.007

Gupta, M. & Goyal, E. (2011). Study the Usage of Mobile Learning Engine in Computer Application Course. IEEE International Conference on Technology for Education

Hahn, J.B.R., Barbosa, D.N.F., Geyer, C.F.R. (2007). Mobile and Ubiquitous Computing in an Innovative Undergraduate Course. Proceedings of the 38th SIGCSE technical symposium on Computer science education. 379 - 383

Han, E., Yang, H. & Jung, K. (2007). Mobile Education through Camera-Equipped Mobile Phones. IEEE. International Conference on Convergence Information Technology.

Huang, Y-P., Chang, T-W., Sandnes, FA. (2008) In: Sandnes, F., Zhang, Y., Rong, C., Yang, L., Ma, J., editors. Ubiquitous Interactive Museum Guide. Berlin/Heidelberg: Springer; 2008. p. 720–31.

Johnson, L., & Laurence, F. (2004). The 2004 horizon report. Austin, Texas: The New Media Consortium.

Johnson, L., Laurence, F., Levine, A., Smith, R., & Stone, S. (2010). The 2010 horizon report. Austin, Texas: The New Media Consortium.d

Koper, R. (2001). Modeling Units of Study from a Pedagogical Perspective: the Pedagogical Meta-model behind EML. Educational Technology Expertise Centre Open University of the Netherlands.

Martín, S., Sancristobal, R.G.E. & Castro, J.P.M. (2009). Convergence of Learning Services. Proceedings of iiWAS 2009. 638-642

Oppermann R, Specht M. (1999) Adaptive mobile museum guide for information and learning on demand. Proceedings of the HCI International '99, the 8th International Conference on Human-Computer Interaction. Munich, Germany; pp. 642–646.

Parodi, E., Vannucci, M., Schwertel, U., Weber, J., Kawase, R. & Niemann, K. (2012). OpenScout. Final version of connector and Mash-Up Implementation. Deliverable WP5.

Pérez-Sanagustín, M., Ramirez-Gonzalez, G., Hernández-Leo, D., Muñoz-Organero, M., Santos, P., Blat, J., Delgado-Kloos, C. (2012). Discovering the campus together: A mobile and computer-based learning experience. Journal of Network and Computer Applications 35 (2012) 176–188

Rahman, A. S. Md. M. & El Saddik A. (2011). Mobile based Multimodal Retrieval and Navigation of Learning Objects using a 3D Car Metaphor. Proceedings of the Third International Conference on Internet Multimedia Computing and Service. 103-107

Rahman, A. S. Md. M. & El Saddik A. (2012). Mobile PointMe-based spatial haptic interaction with annotated media for learning purposes. Journal Article. Springer-Verlag 2012. pp. 1-19

Romero, R., Zarraonandia, T., Aedo, I. & Díaz, P. (2010). Designing Usable Educational Material for English Courses Supported by Mobile Devices. Springer.

Sampson, D.G. & Zervas, P. (2012). Open Access to Mobile Assisted Language Learning supported by the Mobile2Learn Framework. 12th IEEE International Conference on Advanced Learning Technologies.

Sampson, D.G. & Zervas, P. (2008). Enabling Interoperable Mobile Learning: Evaluation results from the use of SMILE PDA Learning Design Player. Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education.

Santana-Mancilla, P.C., García-Ruiz, M.A., Acosta-Diaz, R., Juárez C.U. (2012). Service Oriented Architecture to Support Mexican Secondary Education through Mobile Augmented Reality. ScienceDirect. The 9th International Conference on Mobile Web Information Systems (MobiWIS).

Siadaty, M., Eap, T.M., Jovanovic, J., Gasevic, D., Torniai, C. & Hatala M. (2008). Semantic Technologies for Socially-Enhanced Context-Aware Mobile Learning. Times of Convergence. Technologies Across Learning Contexts. Lecture Notes in Computer Science Volume 5192, pp 413-418.

Su, J-M., Tseng, S-S, Lin, H-Y. & Chen, C-H. (2011). A personalized learning content adaptation mechanism to meet diverse user needs in mobile learning environments Springer Science and Business.

Tabuenca, B., Ternier, S., & Specht, M. (2012). Everyday patterns in lifelong learners to build personal learning ecologies. In M. Specht, J. Multisilta, & M. Sharples (Eds.), Proceedings of the 11th World Conference on Mobile and Contextual Learning 2012 (pp. 86-93). October, 16-18, 2012, Helsinki, Finland.

Ternier, S., Klemke, R., Kalz, M., Van Ulzen, P., & Specht, M. (2012). ARLearn: augmented reality meets augmented virtuality [Special issue]. Journal of Universal Computer Science - Technology for learning across physical and virtual spaces.

Ternier, S., Massart, D., Totsching, M., Klerkx, J. & Duval, E. (2010). The Simple Publishing Interface (SPI). D-Lib Magazine.

Yang M-C. (2007). An Adaptive Framework for Aggregating Mobile Learning Materials. IEEE. International Conference on Advanced Learning Technologies.

Zervas, P., Sampson, D.G. (2010). Enhancing Educational Metadata with Mobile Assisted Language Learning Information. 10th IEEE International Conference on Advanced Learning Technologies.

Edition and production

Name of the publication: eLearning Papers
ISSN: 1887-1542
Publisher: elearningeuropa.info
Edited by: P.A.U. Education, S.L.
Postal address: c/Muntaner 262, 3r, 08021 Barcelona (Spain)
Phone: +34 933 670 400
Email: editorial@elearningeuropa.info
Internet: www.elearningpapers.eu