Hybrid online/offline mobile solutions for accessing open educational resources in areas with poor internet connectivity

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Abstract

Purpose – The purpose of this paper is to present mobile solutions that aid in accessing open educational resources (OERs) in areas that have limited bandwidth resulting in poor internet connectivity and a gap between those with ready access to the online OERs and those without such access.

Design/methodology/approach – A system architecture was designed to support the repository-based, mobile-friendly, and hybrid online/offline characteristics of OERs. In a hybrid online/offline setup, the learner connects to the internet to obtain OERs from the repository via a process called syncing. Afterward, he may view any OER content regardless of whether he is online or offline. Mobile solutions based on Browser-Like Android App (BLAP)/HTTrack and Worona/Corona approaches were successfully implemented and evaluated by 139 respondents using the System Usability Scale.

Findings – BLAP/HTTrack and Worona/Corona solutions were well received. These were found to be both relatively usable, acquiring above-average usability scores of 73.2374 and 71.6546, respectively.

Research limitations/implications – The findings of this study aim to contribute to the literature of hybrid online/offline model that addresses low bandwidth access of OERs in developing countries, which is not historically well provided.

Originality/value – The mobile solutions were designed to help those learners who experience internet connectivity difficulties in accessing OERs efficiently and updating them conveniently.

Keywords Usability, Mobile learning, Hybrid online/offline model, Open educational resources, Syncing

Paper type Research paper

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Introduction

Nowadays, the market for smart devices has seen a rapid growth due to massive consumer interest around the globe that resulted in a shift from using desktop computers to mobile devices for mobility (Miguel *et al.*, 2015). In the Philippines, there is a growing smartphone ownership; in 2013, there were 14.5 million smartphone users, and by the end of 2016, the number of users is projected to reach 29.9 million (eMarketer, 2015). This presents opportunities to use mobile devices in facilitating learning, including open and distance e-learning, in new and innovative ways (Tuliao *et al.*, 2015). One possible example is by enabling learners to use their mobile devices to view learning materials such as open educational resources (OERs).

At present, repository-based OERs are increasingly established (De Vries and Thuss, 2013). The materials and files associated with each OER are stored in a repository, a storage area in the cloud. Whereas before, OERs and mobile devices have nothing to do with each other, storing OERs in repositories allows learners to access them using mobile technology (Ally and Samaka, 2013; De Vries and Thuss, 2013). Ally and Tsinakos (2014) also argued that combining OERs and mobile learning will revolutionize education, especially in developing countries where the use of mobile technology is increasing at an astounding rate.

However, issues remain for providing repository-based OERs. One issue is that many OERs are not suitable for mobile consumption since most commonly used authoring tools lack mobile support (De Vries and Thuss, 2013). Without proper mobile support, users may encounter the following: texts are too small and unreadable; zooming in and zooming out need to be done countless times; and elements and formats are missing due to incompatibility (Pugoy and Figueroa, 2012). In this regard, responsive web design (RWD), a revolutionary web design trend, may address these. RWD is a set of techniques for enabling websites to automatically adjust based on screen sizes and resolutions, ranging from widescreen desktops to tiny smartphones (Hussain and Mkpojiogu, 2015). RWD allows the development and access of mobile-friendly OERs to be less complicated and more convenient.

Another significant issue is poor internet connectivity resulting from limited bandwidth due to the absence of appropriate infrastructure to deliver quality mobile services in developing countries (Shrestha *et al.*, 2010). Austin and Bradley (2005) indicated that accessing and utilizing information and communication technology (ICT) is technically much easier when one has a broadband internet connection. Developing and viewing online OERs would then depend on this factor. However, Shrestha *et al.* stated that internet connectivity is little to none in remote rural areas, where a significant number of educational institutions are located. They further added that even though internet connectivity is present in urban areas, it is inferior to the service provided in developed countries. Moreover, the Philippines is considered to have the second slowest internet connection in Asia, and broadband internet subscriptions in the country are expensive (Gonzales, 2015). Consequently, according to Hassler and Jackson (2010), this limitation affects the users in accessing the internet effectively and satisfactorily. This, in turn, may influence the learning experience. Therefore, as they have noted, a gap exists between those with ready access to the online OERs and those without such access.

A hybrid online/offline model is a possible strategy that can provide OERs in bandwidth-challenged countries (Hassler and Jackson, 2010). In a hybrid setup, the learner connects to the internet to obtain OERs from the repository via syncing. Syncing is a process that only copies new and updated files from the repository to the

mobile device, and this prevents copying the same files that are already copied before (De Leon, n.d.). After syncing, the learner may readily view an OER with or without an internet connection. Hassler and Jackson noted that this kind of solution, most suitable in leading to improvements in low bandwidth OER access, has not been historically well provided. They urged to address this with high priority. They also stated that due to the use of mobile devices for internet access, the hybrid model might finally be confronted after years of technology models changing from offline to online modes and vice versa. Furthermore, hybrid online/offline OERs are more advantageous than completely offline OERs. The former are more appropriate for OERs that are regularly updated. Users would need not to manually download and organize OERs on their mobile devices that may be cumbersome and time consuming.

Hence, this study aims to answer the following research question:

RQ1. What are the possible designs and implementations of acceptable mobile-friendly solutions for repository-based OERs that adopt the hybrid online/offline model?

Objectives of the study

The general objective of this study is to design and implement mobile solutions, including the generation of Android apps, that support the following features:

- OERs that are repository based and mobile friendly.
- Whenever the user is connected to the internet, new and updated OERs are fetched and synchronized from the repository to the mobile device. Syncing is limited to text and images only.
- Regardless of whether the user is connected to the internet or not, he can view and access OERs using the provided mobile apps.

Another objective is to determine whether these mobile solutions are found acceptable by the users, using a survey based on the System Usability Scale (SUS).

Significance of the study

The mobile solutions implemented in this study shall help learners who experience slow and intermittent internet connection. These solutions shall allow them to browse OERs efficiently, and to update them conveniently on their respective mobile devices. Moreover, the findings of this study aim to contribute to the literature of the emerging trend on hybrid online/offline model that addresses low bandwidth access of OERs in developing countries.

Review of related works

As far as hybrid online/offline OERs are concerned, the literature is limited. Nevertheless, related works on offline mobile learning and its use in developing countries, and RWD were examined.

In 2010, Hassler and Jackson listed some initiatives that have partially implemented the hybrid model. These include the MIT OpenCourseWare and the eGranary, both which made a range of educational resources available offline.

In 2012, Menon reported an initiative taken by the Wawasan Open University (WOU) in the development of a course on ICT in Education in the Master of Education degree program. WOU developed a workable model for using, remixing, repurposing, and redistributing OERs. OERs employed in the course were identified and selected

using Google search and advanced search. A study package was developed using eXe, an open source authoring application. The entire course was made available offline on a compact disc (CD), using Hypertext Markup Language or HTML as its base format.

In 2013, Imtinan *et al.* proposed a research project on offline mobile learning to aid in the promotion of literacy in the underprivileged rural areas of Pakistan. Their research objectives include the investigation of mobile learning options on low-cost mobile devices for the underserved and the development of an offline mobile learning framework for developing countries.

In 2015, Figueroa *et al.* created OERs for Philippine biodiversity to promote its protection and conservation. Relevant OERs were curated and later stored in a WordPress-powered repository. OER materials were then organized in a platform that employed the Multiple Paths Approach and RWD principles. Their proposed OER platform acquired a usability score of 72.08.

In 2016, Awodiji and Ogbudinkpa looked into exploring offline and online OERs for primary school instruction in Nigeria. Pupils can access these educational resources with the aid of electronic devices. Their instructors facilitated offline education using presentation tools such as Microsoft PowerPoint. The learning process was delivered using digital video disc, CD, videotape, and over a television channel.

Theoretical framework

OER content and the hybrid online/offline model

According to Hassler and Jackson (2010), there are certain requirements for providing OERs using the hybrid setup. First, any OER provider should be able to easily produce OERs as hybrid online/offline content. Second, any OER consumer, such as the learners or the users, should be able to easily obtain any OER content. Third, any OER content needs to be updatable, i.e. updates are automatic, and these respect the available bandwidth.

One-way file synchronization

De Leon (n.d.) described one-way file synchronization, also known as syncing and mirroring, as a process where files are anticipated to change in one location, and copying occurs in one direction only. One location is considered the source (such as a server, a cloud storage, and a repository), and the other location is called the target (examples include computers, mobile devices, and another server). It is an automatic process that exclusively pushes new and updated files from the source to the target, thereby creating an exact 1:1 replica of the source to the target. As a consequence of this behavior, it prevents copying same old files that are already copied before. Thus, this is more advantageous than manual copying, as it saves time and is less prone to errors (Tridgell, 1999).

Concept of usability

Measuring the usability of a particular system or application is an imperative step to determine the perceptions of its users. According to ISO 9241-11, usability is the extent to which an application can be used with effectiveness, efficiency, and satisfaction by specified users to achieve specified goals in a specified use context (Baharuddin *et al.*, 2013). ISO 9126 also defines usability as the capability of a particular software to be understood, learned, and appealing to users when used under certain conditions (Yen and Bakken, 2012).

Users appear to have a good sense in identifying whether a system is usable or not (Lund, 2001). According to Spencer (2004), if a system is usable, users can accomplish tasks easily. On the other hand, if a system is unusable, users will find it hard to use, and they will not use it. To determine usability, users are asked to evaluate a particular system through a usability test. Spencer added that a usability test is an instrument that collects quantitative measures of efficiency, effectiveness, and satisfaction.

Methodology

System architecture

Figure 1 illustrates the architecture designed to support the repository-based, mobile-friendly, and hybrid online/offline characteristics of OERs. On the server side, the OER repository allows OERs to be organized, created, and modified. WordPress, a content management system (CMS), was used as the repository. The CMS allows OER providers to efficiently manage content without being required to possess prior web programming competencies. Categories were utilized to organize the resources, and tags were employed to make searching easy. For this study, the Philippine biodiversity OERs were used as the content source of the repository. The Philippine biodiversity OERs were developed in a prior research, and its primary purpose is to promote the communication, education, and public awareness on Philippine flora and fauna among various individuals, communities, and institutions (Figueroa *et al.*, 2015). Its repository is accessible via this web address: www.learnbiodiversity.com (Figure 2). Furthermore, the server side contains another component called the mobile enabler, a small program or plugin that ensures that the OERs are mobile friendly.

Conversely, the mobile phone side consists of the viewer and the syncer. The viewer is an app utilized by the user to browse any OER content, regardless of

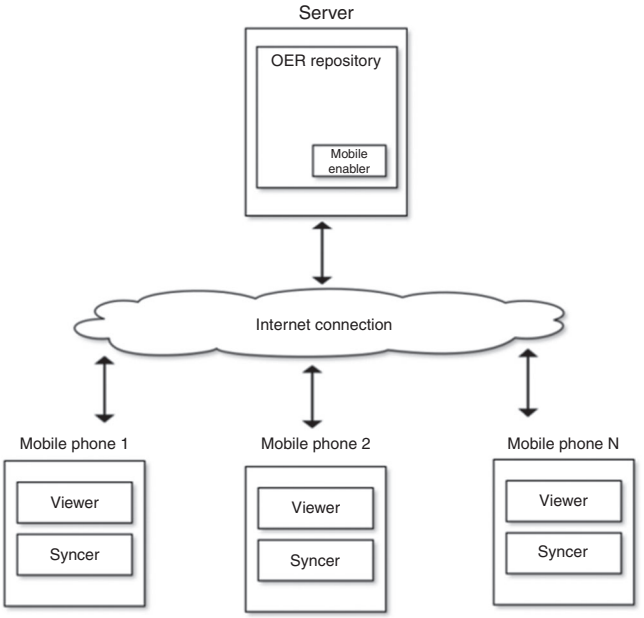

Figure 1.
System architecture for repository-based, mobile-friendly, and hybrid online/offline OERs

his internet connectivity state. Likewise, the syncer, when triggered, automatically fetches updates from the OER repository. Then, it downloads and synchronizes them with the viewer.

Browser-Like Android App (BLAP)/HTTrack approach

In this method, the mobile enabler is the Responsive Theme by CyberChimps. The Responsive Theme was installed in the WordPress-based repository due to its built-in RWD support (Rawlins, 2016). For the viewer, BLAP was developed using the Android Software Development Kit. This native app behaves similarly to a web browser. It can also be set to exclusively access and render the materials from a specified OER repository. BLAP utilizes the WebView class to observe the browser-like behavior. Figure 3 displays a code snippet used to implement BLAP.

Figure 4 shows the app's main page resulting from the code in Figure 3. BLAP resembles a miniature version of the repository website so that its content can fit on mobile device screens. Figure 5 displays a list of all available OERs after the user selects the Resources button in Figure 4. Figure 6 presents an example of an OER content.

For the syncer, an app called HTTrack was installed. HTTrack, widely used and easy to configure, allows downloading of web content for local hosting and viewing (Marill *et al.*, 2004). In effect, it can copy any OER content from the repository to the mobile device. Figure 7 shows the instructions for syncing provided on BLAP.

Worona/Corona approach

In this method, the mobile enabler is a WordPress plugin called Worona, which enables the conversion of a WordPress site to an Android app (Chauhan, 2015). The native app was generated using the Corona Software Development Kit. Unlike the previous

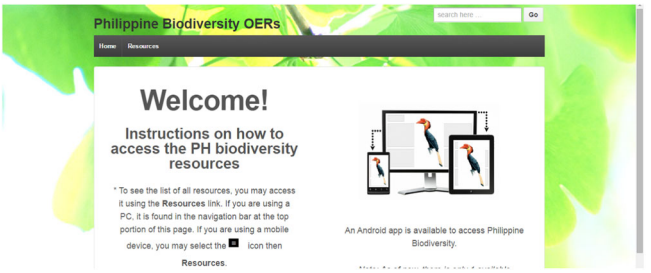

Figure 2.
Home page of the Philippine biodiversity OERs

```
@Override
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    wv = (WebView) findViewById(R.id.webView);
    wv.setWebViewClient(new BLAPWebViewClient());
    wv.getSettings().setJavaScriptEnabled(true);
    String base_url = Environment.getExternalStorageDirectory().getAbsolutePath().toString();
    wv.loadUrl("file:///" + base_url + "/Download/HTTrack/Websites/BIO/www.learnbiodiversity.com/index.html");
}

private class BLAPWebViewClient extends WebViewClient {
    @Override
    public boolean shouldOverrideUrlLoading(WebView view, String url) {
        view.loadUrl(url);
        return true;
    }
```

Figure 3.
Code snippet used to implement the BLAP viewer

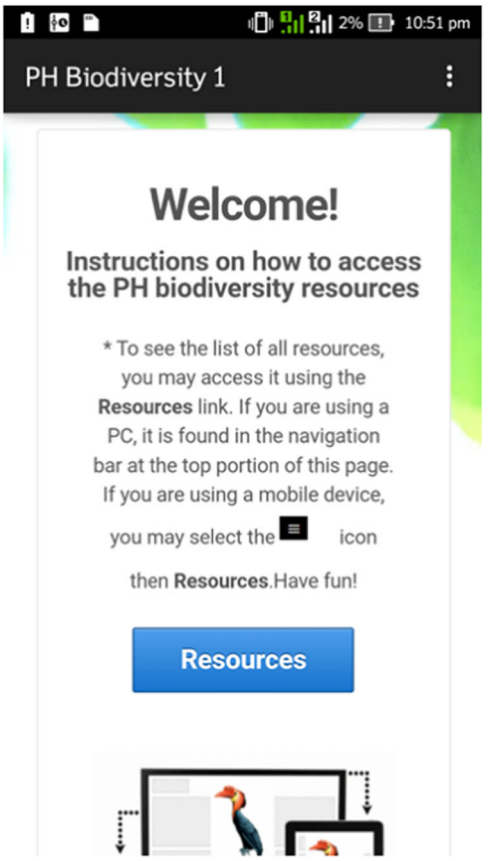

Figure 4.
Philippine biodiversity OERs main page on the BLAP viewer

approach, the said app integrates both the features of the viewer and the syncer. Figure 8 presents a configuration file provided by Corona that can be customized according to the needs of the OER providers. An example of this customization is fixing the web address of the OER repository.

Figure 9 shows the app's main page that enumerates all available OERs. The user interface is minimalist and simpler than BLAP's. Moreover, the sync icon can be selected on the upper right portion of the app to initiate the syncing process. Figure 10 displays an example of an OER content.

Usability evaluation

To evaluate the implemented mobile solutions, 139 respondents were chosen. Respondents are current students of the University of the Philippines Open University under the Faculty of Information and Communication Studies, where open and distance e-learning is being used as the mode of learning. Respondents were asked to each test BLAP/HTTrack and Worona/Corona. Afterward, a survey based on the SUS was given to assess the usability and acceptability of each of the mobile solutions.

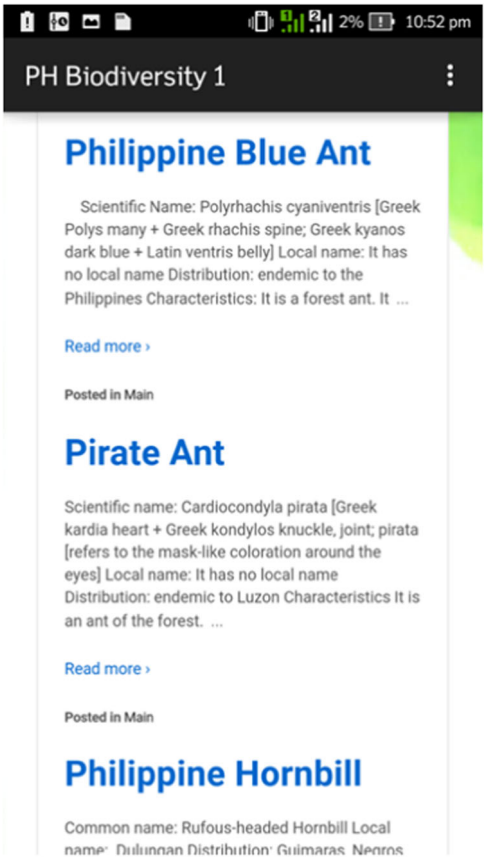

Figure 5.
List of all available OERs on the BLAP viewer

The SUS is a widely recognized industry standard that serves as a quick and reliable tool for measuring usability (Brooke, 2013). Formulated by Brooke (1996), the SUS consists of ten items, which the respondents can rate on a five-point Likert scale, ranging from strongly disagree (1 point) to strongly agree (5 points). The list below shows the survey items:

(1) I think that I would like to use the system frequently.

(2) I found the system unnecessarily complex.

(3) I thought the system was easy to use.

(4) I think that I would need the support of a technical person to be able to use the system.

(5) I found the various functions in the system were well-integrated.

(6) I thought there was too much inconsistency in the system.

(7) I would imagine that most people would learn to use the system very quickly.

(8) I found the system very cumbersome to use.

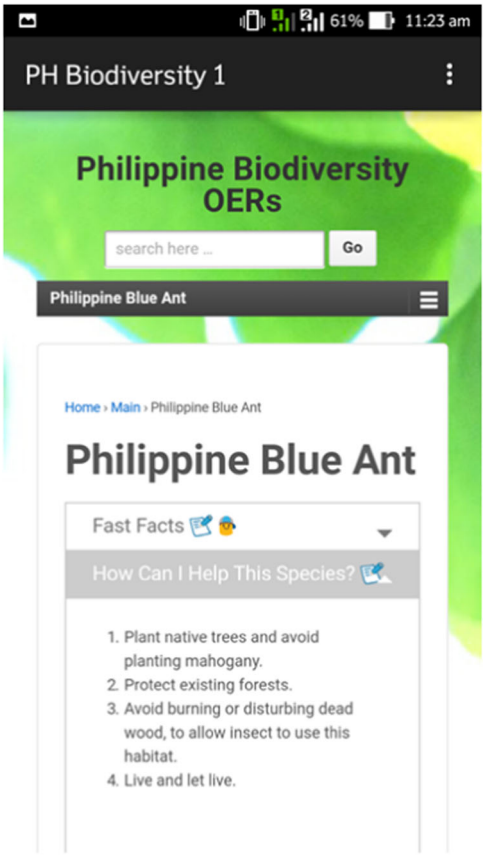

Figure 6.
Sample OER content on the BLAP viewer

(9) I felt very confident using the system.

(10) I needed to learn a lot of things before I could get going with the system.

The usability score from each respondent is derived by applying the following steps:

(1) for odd-numbered items: subtract 1 from the response;

(2) for even-numbered items: subtract the response from 5; and

(3) get the sum of the converted responses and multiply that total by 2.5.

The overall usability score is then computed from the average of the respondents' given usability scores. If the usability score is greater than the global mean score of 68, the solution being evaluated is considered to be relatively usable (Sauro, 2011). The SUS adjective scale, as described in Table I, is used to interpret SUS scores (Bangor *et al.*, 2009).

Furthermore, to compare the mobile solutions, two-tailed paired *t*-test was performed. This is appropriate when the same respondents are asked to evaluate both systems (Sauro and Lewis, 2016). The mean and the standard deviation of the solutions' difference scores are first calculated. Then, obtaining a *p*-value of 0.05 or less implies that the difference in their usability scores is statistically significant.

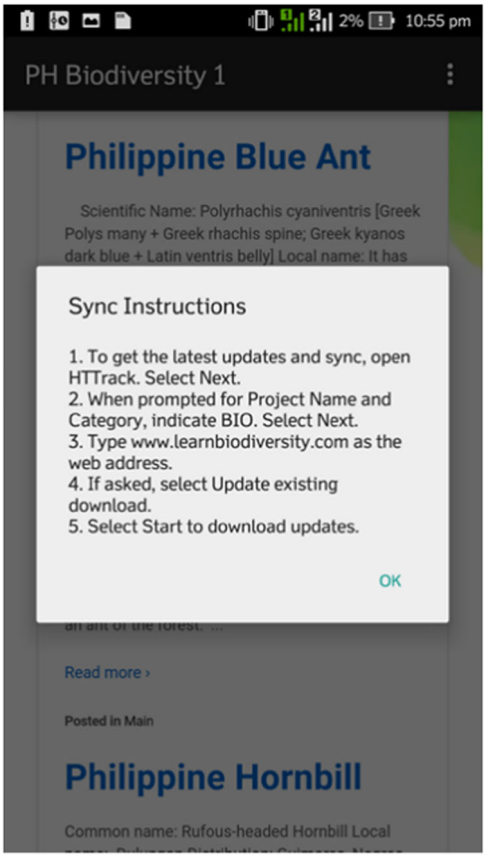

Figure 7.
Sync instructions as shown on the BLAP viewer

```
-- START THE LOG
worona.log:start( { level = "WARNING", reset_log = true, console
= true, file = "log", previous_file = "previous_log" } )

-- WORONA APP CONFIGURATION
worona.current_style       = "default"                    --
Choose your theme.
worona.wp_url              = "http://www.learnbiodiversity.com"
-- Enter the url from which the app will read the data.
worona.app_title           = "PH Biodiversity"            --
Enter the main title of your app.
worona.app_number_of_posts = 20           -- Choose the max
number of posts to be shown in your app. Worona will always
retrieve the latest posts.
worona.content_type        = "post"
```

Figure 8.
Configuration file used to generate the Corona-based app

Aside from the SUS survey, the following questions were also given to the respondents:

(1) Would you recommend using a mobile device for OER access?

(2) Which of the two solutions did you prefer?

(3) Was syncing relevant to your situation?

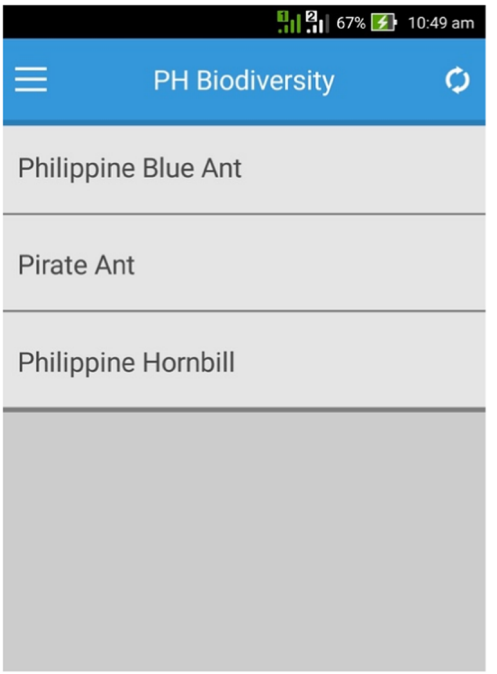

Figure 9.
List of all available OERs on the Corona viewer

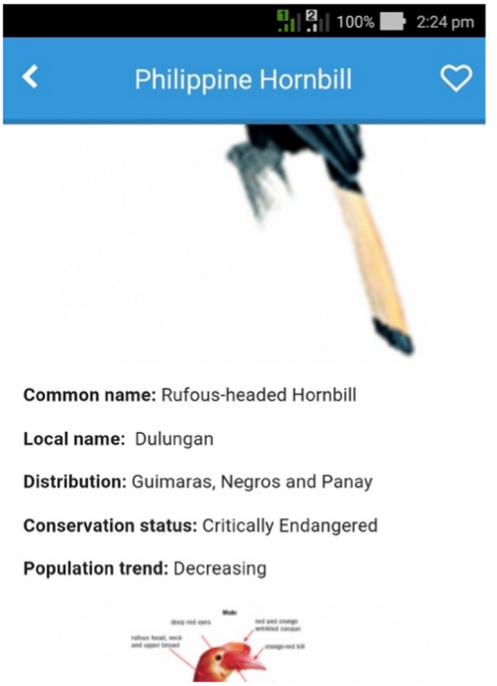

Figure 10.
Sample OER content on the Corona viewer

Results and discussion

Results of the SUS survey

Results showed that BLAP/HTTrack and Worona/Corona obtained overall usability scores of 73.2374 and 71.6546, respectively. Both scores are above the global mean score of 68, implying that the respondents found both solutions to be relatively usable. Based on the SUS adjective scale, BLAP/HTTrack is considered to be an excellent solution, and Worona/Corona is deemed to be a good solution (Table II).

Moreover, notwithstanding the distinct approaches used in implementing the mobile solutions, t -test results revealed that there is no significant difference in their usability scores ($M = 1.5827$, $SD = 16.1826$, $p = 0.2509$). Though BLAP/HTTrack has a higher usability score than Worona/Corona, there is no sufficient evidence to state that the former is easier to use than the latter. It could mean that the solutions are indistinguishable from the perspectives of the respondents, or less likely, Worona/Corona is more usable.

Results of the other survey items

On recommending the use of mobile devices to access OERs, 88 percent of the respondents said that they would support it while the other 12 percent said otherwise.

Figure 11 illustrates that a majority of the respondents prefer BLAP/HTTrack over Worona/Corona: 56 percent preferred BLAP/HTTrack, 35 percent preferred Worona/Corona, and 9 percent preferred neither. According to them, BLAP's advantages include better user interface, better organization, and easier navigation. On the other hand, Worona/Corona has an easier syncing process, but the look and feel is too dull.

Lastly, 77 percent of the respondents agreed that syncing was relevant to their situation while 23 percent disagreed. Those who agreed noted that syncing is practical and helpful to keep materials available even when offline. They do not have constant internet access, and they occasionally visit places where it is not available. On the contrary, those who disagreed said that they always have a good internet connection.

Conclusion and future works

The proposed architecture integrates four essential components: OER repository, mobile enabler, viewer, and syncer. Hence, this allows hybrid online/offline OERs to be

Usability score	Adjective
0-25	Worst imaginable
25-39	Poor
39-52	OK
52-73	Good
73-85	Excellent
85-100	Best imaginable

Table I.
The SUS adjective scale

Mobile solution	Usability score	Usable?	Usability adjective
BLAP/HTTrack	73.2374	Yes	Excellent
Worona/Corona	71.6546	Yes	Good

Table II.
Summary of SUS scores and adjectives for the mobile solutions

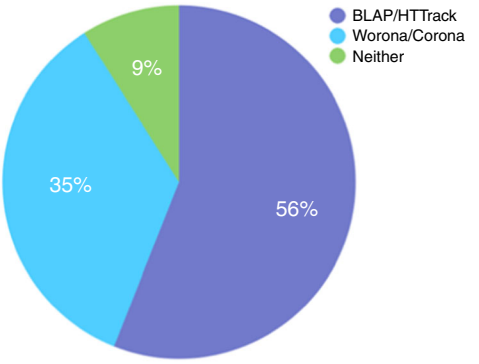

Figure 11.
Respondents' preferred mobile solutions

successfully implemented using the BLAP/HTTrack and Worona/Corona mobile solutions. Both solutions were well received and considered to be relevant, as evidenced by the above-average usability scores and feedback from the respondents. Furthermore, the architecture and the mobile solutions developed in this study may serve as starting points to assist in open and distance e-learning in areas with poor internet connectivity.

In the future, the enhancement of the syncing process can be considered. Syncing OER materials in other formats such as videos and audios can be included. Syncing can be further optimized to respect the limited bandwidth, considering the varying OER file sizes. Also, the effect of utilizing these mobile solutions on the learners' cognitive experiences can be examined and analyzed as well.

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