LEARNING BEACONS – USING THE INTERNET OF THINGS TO DELIVER HEALTH AND SAFETY MATERIALS IN STUDENT WORKSHOPS

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Abstract

Health and safety is an important part of student education within a wide range of both engineering and applied art fields. Until now, health and safety information for specific machinery was commonly held only as paper copies for student reference. The introduction of Internet of Things (IoT) technologies mean that it is possible to provide highly-localised health and safety information as well as short instructional videos detailing the safe operation of workshop equipment using mobile technology.

Each workshop has been equipped with a "learning beacon" – a Bluetooth Low Energy beacon that points mobile devices towards web pages. Students can download the Physical Web app on their mobile device and then use it to access the web page pointed to by the local beacon. The content can be easily updated using Google Sites and the university's own Sharepoint system, making it easy for teaching staff to maintain the content and to add and remove teaching materials as appropriate. Monitoring of the usage of the web pages showed that approximately 25% of the student cohort made use of this resource. This pilot project is a collaboration between the University of Wales Trinity St. David's School of Applied Computing and the School of Applied Art and Design.

Keywords: IoT, Health and Safety, Physical Web.

1 INTRODUCTION

This paper documents a pilot study carried out in the School of Applied Art and Design at the University of Wales Trinity St. David with the support and collaboration of the university's School of Applied Computing. Swansea School of Art includes the historic Welsh School of Architectural Glass (founded in 1935). It teaches practical skills in both architectural and decorative glass.

To support these skills students have access to a set of workshops with specialised industrial machinery for cutting, heating, etching and treating glass. High-quality Health & Safety training is a legal requirement, and easy access to instruction manuals for these devices is essential. Currently students are given live training on health and safety issues and then rely on either paper copies of these held in each workshop or, more commonly, seek out the technician-demonstrator to ask his advice.

1.1 'Just-In-Place' (JIP) learning

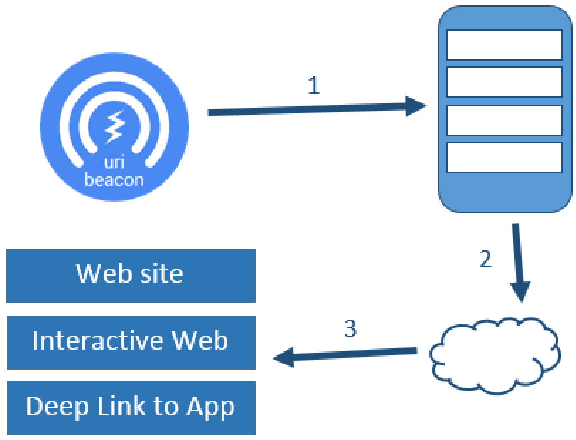
Roschelle *et al* [1] suggest four promising trends for pedagogical research: Incidental Learning, Context-based Learning, Embodied Learning and Analytics of Emotions. These aim to deliver *"[…] mentoring, timely information presentation, and responsiveness to the learner's physical and emotional processes*." In this case the learner is presented with multimedia demonstrations (i.e. mentoring) when it is needed (i.e. timely) in the workshop location where the student is working (i.e. relevent to the learner's physical processes). This provides context-based learning outside of normal teaching hours, allowing the user access to resources that can be played on handheld devices.

These provide the benefit of just-in-time learning – students in workplace contexts learn by doing and need training materials that are accessible at the point of need. The localized nature of the learning beacons allows us to extend this paradigm to 'just-in-place' learning – rather than accessing a large site of all available material such as Moodle or Blackboard the student is only presented with materials relevant to their location, i.e. the local workshops. This flexible access to key elements of learning enhances students' professional competence, and provides for direct access and application in the workplace as supported by Mathew [2].

1.2 The Physical Web

Launched by Google in 2014, the Physical Web [3] is an IoT project that aims to provide location-based information through Open Source technologies using Bluetooth Low Energy (BLE) beacons. The Learning Beacon project uses Eddystone beacons placed in each of the glass workshops.

The beacons broadcast a URL using the Eddystone protocol using BLE (Fig. 1). This can be picked up by any mobile device using either an appropriate app or the Google Chrome browser. The mobile device itself needs a 3G/4G/wifi connection to the Internet, which it then uses to connect to the web resource identified by the beacon's URL The beacon itself does not need to be connected to the Internet, nor does the mobile device need to connect to the beacon. The URL broadcast by the beacon can lead either to a web site, to an interactive location within a website, or can provide a deep link into an app.



1. The UriBeacon broadcasts a URL via Bluetooth BLE
2. A mobile device detects the Bluetooth beacon and connects to the URL via its own web connection
3. The URL can point to a website, an interactive web location of a deep link into an app

Figure 1. Accessing information via the Physical Web.

The technology is inexpensive and does not need any specialised wifi infrastructure. The beacons can be wall-mounted and their batteries can last for up to a year and are easy to replace.

2 METHODOLOGY

The technology used to address this challenge is a small (5cm diameter) battery-powered BLE transmitter together with a free app available on all major mobile platforms. The beacons cost between £11 and £25 each, and are battery powered (although mains-powered beacons are also available). The beacon transmits the URL of a secure web page, which the app detects and displays as a clickable link to that page. The user simply selects the local learning beacon in the app and their mobile device will use its default local network to connect to the web page. The user can then view or bookmark materials as desired.

This approach allows the students to access the materials using handheld devices of their choice. It also broadens the range of formats that can be used for such materials. Prior to this, all health and safety materials and equipment instruction manuals have only been available as paper copies kept in the lab; using the new system students have access to electronic copies of these both in the workshop and at home. This is particularly useful for students to identify any extra personal protective equipment they might need when operating machinery or carrying out particular fabrication processes.

The initial plan for the use of the learning beacons was to simply provide electronic copies of the operational instructions for each machine in a workshop. During early discussions about the project it became clear that the materials could be expanded to include video of how to use the machines, and to demonstrate techniques that include the machines' use.

As a result a set of web pages were set up using Google Sites (necessary to provide the security protocols required for the learning beacons) that linked to documents and video resources held on the university's Sharepoint system. These include:

- Text process instructions, e.g. how to prepare a kiln base and shelf
- Equipment operation manuals, e.g. kiln programming manuals
- Health and safety documents, e.g. Material Safety Data Sheets for materials used in the workshop
- Process videos, e.g. programming a kiln controller

The Google Site is accessible from outside the university network but the videos themselves can only be accessed using a UWTSD account, requiring users to log onto the main university system before they can access the videos. Viewing-only access is granted to users within the UWTSD domain.

It should be pointed out that none of this is intended to replace health and safety briefings (students are not allowed to use equipment until they have been formally trained in its use) but rather to reinforce their learning. If, for instance, a student has been trained to change the belt on the linisher but has not performed this task for several months, they can now easily refresh their knowledge using either the linisher manual or by watching a demonstration video of the process.

In using the learning beacons, students gain immediate access to the information they need. This contrasts with the previous situation, where students would try to find the technician in order to ask questions. This might take some time, which naturally interrupted the flow of learning.

The web pages themselves are easy to update, as Google Sites use a WYSIWYG editing paradigm. This means that staff in the Glass department can easily maintain the contents of the pages without having to learn HTML. Short videos can be recorded with a smartphone and uploaded to Sharepoint for inclusion on the website. This allows tutors to upload time-limited teaching videos as well as more general instructional videos, then just as easily remove them. It thus provides a supporting technology to Moodle, which is topic-based rather than location-based.

3 RESULTS

During the three month period of the pilot study the initial results showed that they were being used 2-3 times a week. With a small test audience (~12) who are expected to use the material infrequently, this is considered an acceptable use rate. As a result, the project is continuing into the next full academic year to see how the beacons are used when fully integrated into the teaching process (rather than as something that appeared over half-way through the year).

An unexpected positive result was that during an official health and safety audit the inspectors were both interested in and impressed by the project's use as an adjunct to common health and safety practice.

4 CONCLUSIONS

This highly practical application of cutting edge computing technology within a non-computing environment shows how emerging technologies can significantly enhance teaching and learning. In this case an IoT application has created new flexible learning scenarios that can clearly be transferred to other disciplines that use workshop-based teaching and learning techniques.

It is intended that the beacons will remain in place for the foreseeable future, although they may be replaced by mains-powered beacons to minimize the chance of dead batteries limiting access to the materials. A further problem encountered was the strength of the wi-fi signal in the area of the workshops. The workshops are in the basement of the Alexandra Road building, a significant 19^{th}-century civic building with solid walls, with the result that the wi-fi signal connecting students to the university network is not particularly strong. Due to this the School is looking at not only upgrading the local wi-fi but also providing a touch-screen device in one of the hall areas which would allow students access to the beacon landing pages if they cannot get a wi-fi or phone signal in the workshops.

Further ideas for using the learning beacons are also being examined. It would be possible, for instance, to use the technology to create 'showcase beacons' that link through to a series of pages showcasing the work of the school's artists. This would be available outside the university as well as within it. Similarly the beacons could be reconfigured as ‘advertising beacons’, directing visitors to the university website or to the website of an individual faculty or school.

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