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EDUCATE on SITE: user acceptance of mobile web applications in architectural education on sustainable environmental design
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To enhance knowledge of sustainability in the education of disciplines of the built environment, and disseminate know-how and exemplars of best practice in sustainable design, a European project EDUCATE (Environmental Design in University Curricula and Architectural Training in Europe, http://www.educate-sustainability.eu) was set up in 2009 under the co-ordination of the University of Nottingham, Department of Architecture and Built Environment and School of Computer Science.

Currently in its concluding stage, EDUCATE has engaged seven European universities and several professional bodies for three years, with the aim of tackling pedagogical barriers to the integration of sustainability in university curricula and in the practice of architecture. In order to support this process, an interactive web portal was designed and developed at the University of Nottingham. The EDUCATE Portal offers a range of functionalities. Key among these, is the EDUCATE Knowledge Base (KB), which represents the collected expertise of the seven consortium partners of key concepts in sustainable architectural design, organised into: ‘Issues and Principles’, ‘Applications and Case Studies’, and ‘Tools’. Further functionalities of the Portal allow interaction between users (e.g. students, experts, professionals), such as ‘Ask a Question’, participating in a ‘Discussion Forum’, consulting ‘Readings Lists’ of topics or accessing ‘Frequently Asked Questions’.

The EDUCATE Portal was initially made accessible to all the staff and students at EDUCATE partner institutions to support teaching and learning of sustainable environmental design, and was subsequently used to facilitate an international competition on sustainable design. Under the banner of EDUCATE Prize, the competition involved 64 universities worldwide, whose registered academics and students were given access to the EDUCATE Knowledge Base.

The EDUCATE Portal was originally intended solely for use in the design studio and continuing professional development (CPD) settings. However, initial feedback obtained from an online survey of EDUCATE Portal target groups highlighted that more and more users are utilising their mobile devices to search for information and interact with others on the move.

Increasingly, web services are introducing either mobile versions of their site or special applications (apps) designed to be accessed from a mobile phone or a tablet. The relatively high screen resolution, powerful processing units and fast internet connectivity of modern mobile devices allow greater flexibility in accessing web-based information, and, critically, the possibility of situated learning, allowing users to combine cognitive learning and experience in situ.

In response to this initial feedback, a prototype of a mobile application for teaching and learning in sustainability – EDUCATE on SITE (Situated Education) – was developed in order to support some of the key functionalities of the EDUCATE Portal. Using this mobile service, users are able to experience real-world examples of buildings and techniques described in the EDUCATE Knowledge Base and access relevant information on site. Questions can be asked and/or discussed directly on site and the camera built in to most modern mobile devices makes it possible to attach photos to illustrate questions.

The case study reported on page 3 was set up with the aim of investigating user acceptance of the prototype mobile device service for the EDUCATE Portal, analysing changes in user behaviour and evaluating how mobile access to the EDUCATE Portal functionalities could be better implemented and supported. The results obtained indicate that access to information and learning tools on mobile devices holds significant promise in promoting situated and interactive learning to both naive and expert users in the field of education for sustainable environmental design. In this context, the development of specific applications – purposely designed for mobile devices – proves to be more easily accepted by the users and could allow a more comprehensive knowledge transfer, encompassing at once theoretical (acquisition of principles), experiential (practical visualisation) and analytic (critical evaluation) cognitive domains.
Introduction: The EDUCATE Project

Promoting sustainability in the design of the built environment is a core activity for many academic and professional institutions worldwide. In recognition of this, the EU-funded project EDUCATE (Environmental Design in University Curricula and Architectural Training in Europe) started in 2009 under the co-ordination of the University of Nottingham, Department of Architecture and Built Environment and School of Computer Science.

EDUCATE was funded by the European Commission’s Executive Agency for Competitiveness and Innovation (EACI) under the ‘Intelligent Energy Europe’ Programme 2008 and involved a consortium of seven European academic partners: the University of Nottingham (United Kingdom); the Architectural Association School of Architecture (United Kingdom); the Catholic University of Louvain (Belgium); the Technical University of Munich (Germany); the Department DATA, University of Rome La Sapienza (Italy); the Seminar of Architecture and Environment, SAMA S.C. (Spain); and the Budapest University of Technology and Economics (Hungary).

The project also received the support of all Chambers of Architects in the six participating countries, of internationally renowned building professionals in the field of sustainable architecture, of experts of cognate disciplines (e.g. education, engineering, information technology, ecology, etc.) and of associations of educators and practitioners, which have supported the consortium in fostering the integration of sustainable environmental design in architectural education and practice and the harmonisation of academic curricula as well as of the criteria and conditions for accreditation and professional qualification across Europe and beyond (Altomonte, 2009).

The mission of EDUCATE was to “foster knowledge and skills in sustainable environmental design aiming to achieve comfort, delight, well-being and energy efficiency in new and existing buildings. This will be promoted and demonstrated within a culturally, economically and socially viable design process, at all stages of architectural education” (EDUCATE, 2009a).

To achieve these aims, the following objectives were identified:

• remove pedagogical barriers to the integration of principles of sustainable environmental design within a creative architectural discourse;

• define and test a curriculum and pedagogical framework that bridges current divides between sustainability-related technical information and the design studio at different levels and stages of architectural education to meet current professional demands and expectations;

• in concert with Chambers of Architects, propose homogeneous criteria for accreditation of architectural curricula and professional registration that clearly establish the level of awareness, knowledge, understanding and skill in sustainable environmental design expected of graduates qualifying as architects;

• promote and disseminate environmental know-how and exemplars of best practice among students, educators, building professionals and the public, fostering change of behaviour and expectations towards the integration of sustainable design in architecture. (EDUCATE, 2009b)

The EDUCATE Portal: analysis of technology and functionalities

In order to support the achievement of the stated objectives of the EDUCATE project, a web-based portal – the EDUCATE Portal – has been developed. The vision for the EDUCATE Portal was to create an interactive intelligent e-learning system to facilitate the transfer of information, know-how, results and methodologies, provide interactive support to students and practitioners, and reinforce an integrated approach to principles of sustainability and energy efficiency in architectural education and practice.
In developing the Portal, use has been made of existing software frameworks and components. However, no existing system (or combination of systems) could support the range of functionalities anticipated for the EDUCATE Portal, so significant development of new bespoke software has been necessary to implement the Portal structure. The design of the Portal is based on an open source Content Management System (CMS) called Drupal. This system consists of a core system that can be extended by installing so-called plug-ins. In relation to its structure, the Portal has been designed to offer the following functionalities:

- Knowledge Base;
- Reading Lists;
- Discussion Forum;
- Knowledge Base Questions;
- Frequently Asked Questions;
- Studio Space.

**Knowledge Base**

The EDUCATE Knowledge Base (KB) represents the collected expertise of the seven consortium members of key concepts in sustainable architectural design. The Knowledge Base has been structured in a cognitive framework organised in three main parts: ‘Issues and Principles’, ‘Applications and Case Studies’ and ‘Tools’. Each of the three parts is organised in a primary ontology – generally subdivided into categories and clusters – which forms a key element of content retrieval. Each cluster groups a related set of topics (Issues and Principles), case studies (Applications and Case Studies) and practical resources (Tools). The material relating to each topic, case study and tool, is presented in the form of five aspects or 'tabs' (Figure 1), which present different views on the contents. The Knowledge Base is not limited to a tree structure (i.e., sections and subsections), but rather it is possible to add links between content in different sections of the Knowledge Base and make use of links to external references where appropriate.

![Figure 1: A snapshot from the web-based EDUCATE Knowledge Base](image)

**Reading lists**

In order to help students find information concerning a specific topic, case study or tool, an expert or a lecturer at any of the partner institutions can create a ‘reading list’ consisting of an ordered, annotated set of links to the KB that are particularly relevant to a specific coursework or design project and which form part of the background material for a module. These reading lists are automatically created under the sub-menu item of the affiliation that the author belongs to. Each student is able to access all the reading lists set up by each of the seven academic partners, in order to foster exchange of methodologies, pedagogical techniques, and contents of modules across participating organisations.

**Discussion Forum**

The Discussion Forum supports interaction between groups of users (e.g., academics, students, and professionals), where comments, posts, information, data, links to relevant websites, etc. can be posted and shared with other users. Depending on institution and course-specific settings, Discussion Forums are available to all registered users, to all students from a specific university or can be limited to a group of students (e.g., those enrolled in a single module).
Knowledge Base Questions

Students can ‘Ask a Question’ about a specific KB topic, case study or tool directly on the Portal, which is answered by an appropriate expert from within the consortium. The question and the answer may or may not be visible to other users in the same group, at the discretion of the expert. The expert may decide to make a question and an answer public to all students from their institution, by transferring them to the ‘Frequently Asked Questions’. When asking a question, students by default agree on their question and the relative answer to be published in the FAQ section. Conversely, they are required to untick a box if they do not provide consent for their question to be made public.

Frequently Asked Questions (FAQs)

The ‘Frequently Asked Questions’ (FAQs) provide answers to the most frequently asked questions on topics, case studies or tools featured in the KB. The questions and answers are grouped into the same categories as the KB itself. Thus, users are able to see the FAQs per category of interest without the need to search the whole FAQs.

Studio Space

This functionality was designed to support the development and assessment of design studio work. Students enrolled in a specific design studio may be required to upload work for interim assessment a number of times during the course of a project. Each student can create folders containing their uploaded work. Folders may be accessible only by the student and the studio tutor, or by the other members of the student’s design studio or group, depending on the organisation of the design tasks. Additionally, a student can mark a folder to indicate a submission for a design task, therefore minimising the need to print out work and submit it to the tutor. If required by the institution and/or their module pedagogy, students may also have access to the work of other students to provide peer feedback. The degree of access allowed is configurable to meet the needs of the particular project/group/institution and the stage of the work (interim or final). Access to uploaded interim work is typically limited to the tutor. Access to finalised work (i.e. following completion of the project) may be wider (EDUCATE, 2011a).

Throughout the development of the EDUCATE project, the Portal has been made accessible to all the staff and students at EDUCATE partner institutions to support teaching and learning activities in sustainable environmental design. Different user groups have been provided with features tailored to the pedagogical practices at each academic organisation. In collaboration with Chambers of Architects, building professionals have also been invited to trial the use of the EDUCATE Portal to support continuing professional development (CPD) activities. During the testing phases of the EDUCATE Portal, a total of 1,580 individual accounts were provided to academics, students and professionals affiliated with EDUCATE partner organisations. In addition, the EDUCATE Portal was also used to facilitate an international competition on sustainable design, the EDUCATE Prize, which involved 64 universities worldwide, with 380 new accounts being opened for academics and students registering to the competition.

The EDUCATE Portal and mobile devices

The EDUCATE Portal was initially designed to be used within a design studio or professional office setting. Increasingly, websites are introducing either mobile versions of their site or special applications (apps) designed for access from a mobile phone or a tablet. The relatively high screen resolution, powerful processing units and fast internet connectivity of modern mobile devices allow greater flexibility in accessing web-based information.

In the context of EDUCATE, access from mobile devices offers additional flexibility, and, critically, the possibility of situated learning, allowing users to combine cognitive learning and experience in situ. Using a mobile device, students can experience real-world examples of the buildings and techniques described in the KB, and are able to access relevant information from the KB on site. Questions can be asked and/or discussed directly on site and the fact that most modern mobile devices are equipped with a camera makes it possible to attach photos to the questions.

In an online survey, a significant number of EDUCATE Portal target groups expressed interest in accessing the functionalities of the Portal from mobile devices, in order to support more flexible exchange of information and interaction with tutors and peers. It was therefore decided to implement access to the EDUCATE Portal from mobile devices.

The remainder of this report briefly presents the technical background to implementing a mobile service, motivates the implementation of an app, EDUCATE on SITE, and summarises the results of a field test designed to evaluate the effectiveness of the app compared to accessing the EDUCATE Portal using the browser of a mobile phone or tablet.
EDUCATE on SITE: technical background

There are two methods that can be used to implement access to the Portal from mobile devices:

1. **Theming**: Using a special theme (or special themes for different mobile devices) optimised for mobile devices to display content via the device’s (micro) browser. To be able to use this approach, the CMS has to support multiple themes and a method to automatically switch a theme depending on the capabilities of the connected client (identify mobile device browser).

2. **App and Web Service**: Using an application on the mobile device to display the content from the web site. To be able to use this approach, the CMS should support a way to retrieve the raw content, therefore the CMS has to offer any way to support a Web Service.

In order to select the best approach to present the data on a mobile device screen, one has to take the constraints of mobile devices as well as the constraints of the CMS into account (W3C, 2008 and 2011b; Drupal, 2011). One of the biggest constraints of mobile devices, besides connectivity, is their screen size and resolution. This is particularly true for mobile phones, which typically have small, low resolution screens. As a result, content must be optimised. Although it is possible to optimise the content for a mobile device browser, in many cases some screen space is wasted. The reason for this is that a mobile web site must contain navigation elements that are difficult to hide, as well as the browser navigation elements. Another problem with most CMS is that images are not optimised on the fly for a mobile device. A standard way to adapt images for mobile phone screens is to adjust them via CSS (client side scaling); however, transferring the high resolution images requires more bandwidth and can increase costs for end users.

These problems can be solved by the use of an application; however, an application depends on the mobile device operating system. Therefore, it is necessary to develop such an application for every mobile device operating system. In order to improve apparent connectivity, content has to be cached at the client side. As a result, already accessed content does not have to be downloaded, saving bandwidth and speeding up the loading time. Generating and maintaining local cached data is not possible with a mobile device’s browser. The advantages and disadvantages of the two approaches are summarised below:

**Advantages of using the device’s (micro) browser:**
- this approach is supported by every internet-enabled mobile device;
- the look and feel is closer to a desktop version (or switch to desktop version on ‘big screen devices’) thus less/no need to ‘learn’ a new interface.

**Disadvantages of using the device’s (micro) browser:**
- limited optimisation: browser address bar always visible, adjustment to screen/image size;
- not all HTML/CSS and plug-ins supported (FLASH/HTML5);
- file upload not available on all mobile devices (iOS);
- no reliable offline mode available (browser may or may not cache files).

**Advantages of using a native application:**
- application can be optimised to the screen;
- offline mode possible.

**Disadvantages of using a native application:**
- different ‘applications’ for different mobile OS required (iOS, Android, Windows Mobile, Symbian);
- look and feel might be different to web version, users need to ‘learn’ another interface.

For a proof of concept case study, the need to implement different applications for each mobile OS is not an issue, and it was decided to implement an application for Android-based mobile phones and tablets. The field test described below thus focused on the functionality and usability of the Android app, and the degree to which the greater flexibility in the use of screen space and interaction allowed by an app can offset the lack of familiarity and the need to learn a new interface.
EDUCATE on SITE: Android app prototype

The native application approach was implemented as an app for Android-based OS devices – EDUCATE on SITE (Situated Education). The app supports the key capabilities of the EDUCATE Portal that are useful in a mobile application, specifically:

- Knowledge Base;
- Discussion Forum;
- Knowledge Base Questions;
- Frequently Asked Questions.

In addition, the Android application made it possible to realise a location-based service. This service shows the user’s position on a Google map and overlays this map with places near the user that are referenced in the EDUCATE Knowledge Base. Selecting any of these places by clicking on the screen shows some basic information and an additional link to the KB where the full information is available.

In order to implement this approach, the application on the mobile device has to access data from the EDUCATE Portal. This can be achieved by the use of a so called web service. The three most commonly used ones are: Simple Object Access Protocol, SOAP (W3C, 2011a); Remote Procedure Call, RPC; and Representational state transfer, REST (Rodriguez, 2008). XML-RPC (XML-RPC, 2011) is built into the Drupal CMS, whereas REST was still in beta when the project began. XML-RPC was therefore adopted for the prototype.

Features of the Application

After launching the EDUCATE on SITE application, the users see the start screen (Figure 2), where they can choose which functionality to use. Figure 3 shows the new location-based service called SITE-map, which uses a Google map to overlay the user’s position and interesting buildings from the EDUCATE KB close to the user’s position. A user can use the SITE-map service to search for a design example close to her/his current position, find an example building ‘in the real world’, receive notifications when an exemplar building of interest is close to his/her position, and upload a photo of a building and ask a lecturer/tutor if the building fits or violates a special design guideline. Figure 4 shows the screen shot of the ‘Knowledge Base Questions’ functionality, which allows users to ask a question related to a Knowledge Base topic.

Figure 2: Start screen of app            Figure 3: SITE-map            Figure 4: KB Questions

Figure 5: A snapshot of a Knowledge Base topic on the EDUCATE on SITE app
Given the limited time available for this case study, the field test focused on the Knowledge Base and the Knowledge Base Questions functionalities of the app, while the other capabilities (Discussion Forums and Frequently Asked Questions) were disabled (i.e. buttons not clickable).

Methodology for evaluation

In order to evaluate the acceptance of a mobile version of the EDUCATE Portal, an initial survey was conducted in which all Portal users were asked to fill out an online questionnaire (pre-questionnaire). The results of the pre-questionnaire were used to define the users’ attitude towards the mobile web in general, as well as the EDUCATE Portal in particular.

Following the collection of this initial feedback, a field test was organised, in which selected users were asked to use mobile devices to access information on the EDUCATE Portal, either via its web-based version or via the EDUCATE on SITE application. Eleven students were selected for the field test. These users were all from the Department of Architecture and Built Environment at the University of Nottingham, with four students enrolled in the second year of the Bachelors degree in Architecture (undergraduate degree, second-year of the architectural curriculum), six students enrolled in the first year of the Diploma in Architecture (graduate degree, fifth year of the architectural curriculum) and one student from the second-year of the Diploma in Architecture (graduate degree, sixth year of the architectural curriculum).

Another survey (post-questionnaire) was conducted directly after the field test. The results obtained in the post-questionnaire were compared with the results of the pre-questionnaire in order to assess whether there had been any change in user attitudes. Additionally, feedback was sought from all participants in the field test through an informal discussion.

During the development of the evaluation methodology, it was hypothesised that users would prefer the Android application on mobile phones (small screen) in contrast to devices with larger screens (tablets), where the web-based version would be preferred. In order to test this hypothesis, users in the field test were provided also with a tablet and some of the questions in the post-questionnaire were specifically formulated so as to address such hypothesis.

The pre-questionnaire

To establish users’ preferences regarding which Portal services should be made available on mobile devices and to recruit users for the field test, a request to complete a specially created online questionnaire was sent to all the EDUCATE Portal users. Below, we briefly summarise the key results from the questionnaire. All questions of the pre-questionnaire can be found at: [http://www.educate-sustainability.eu/educate-on-site/questionnaire#pre](http://www.educate-sustainability.eu/educate-on-site/questionnaire#pre)

Pre-questionnaire: all Portal users

Approximately 25% (394) of the Portal users, mainly located in the UK, Spain and Italy, responded to the survey. More than the half of the users (64%) stated that they regularly accessed the internet using their mobile device. The most commonly used application is Google search/maps (80%) followed by Facebook (63%), while fewer use Twitter (37%). Almost two-thirds of the respondents (65%) stated they would use a mobile application to connect to the Portal if available. According to the users’ responses, the most important functionality of the Portal that should be made available on mobile devices is the KB (83%), followed by the Ask a Question (78%) and the Frequently Asked Questions (76%) functionality. The Discussion Forum functionality was seen as less important (72%), perhaps because it involves more typing on the mobile device. However, the demand was considered sufficiently high to include this functionality in the app.

Pre-questionnaire: field test users

The responses given by the 11 students participating in the field test to the pre-questionnaire were compared to the results for all users, in order to determine how representative the responses provided by the field test users were in comparison to those of users of the EDUCATE Portal in general. This revealed that the responses of the participants in the field test are in general comparable to those of Portal users. However, this result has to be viewed with caution due to the low number of field test participants (11 field test users, less than 1% of all Portal users), which may not constitute a sufficiently representative sample. Nevertheless, although results cannot be generalised, it is still possible to extrapolate a “tendency” of users’ likes and dislikes from the results obtained. Table 1 summarises the differences between the field test users and all EDUCATE Portal users.
Table 1: Comparison of results between Portal users and field test users

<table>
<thead>
<tr>
<th>Question</th>
<th>All Portal users</th>
<th>Field test users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularly access the internet using their mobile device</td>
<td>64%</td>
<td>60%</td>
</tr>
<tr>
<td>Most commonly used application to connect to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Google search/maps</td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td>Facebook</td>
<td>63%</td>
<td>70%</td>
</tr>
<tr>
<td>Twitter</td>
<td>37%</td>
<td>40%</td>
</tr>
<tr>
<td>Would use a mobile application to connect to the Portal if available</td>
<td>64%</td>
<td>80%</td>
</tr>
<tr>
<td>Functionality of the Portal that should be made available on mobile devices:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge Base</td>
<td>83%</td>
<td>100%</td>
</tr>
<tr>
<td>Ask a Question</td>
<td>78%</td>
<td>90%</td>
</tr>
<tr>
<td>Frequently Asked Question</td>
<td>76%</td>
<td>100%</td>
</tr>
<tr>
<td>Discussion Forum</td>
<td>72%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Interestingly, two out of the 11 field test users had stated in the pre-questionnaire that they would not use a mobile version of the EDUCATE Portal or an application, and three stated that they would not be willing to participate in a field test. The reason given was that they did not have a suitable mobile phone and/or they were not willing to pay to download content. By providing mobile phones for some of the users, it was possible to resolve these problems. However, participants using a borrowed device often lacked familiarity with its operation, and were unable to distinguish between a problem with the application and the mobile device in general not functioning properly (e.g. broken internet connection). Additionally, these users were not familiar with a ‘smartphone OS’ and the various new possibilities that such a modern device offers. They were used to a ‘simple mobile phone’ with voice call, SMS and perhaps MMS functionality. These issues have been considered when analysing the results.

Preparation for the field test

The field test was carried out on 15 February 2012 at the University of Nottingham, Jubilee Campus. Jubilee Campus is a purpose-built University campus, whose initial phase was opened in December 1999. It incorporates many features of sustainable environmental design, and thus forms an ideal location for the field test. To support the field test, a case study describing the Jubilee Campus was prepared by one of the EDUCATE experts and included in the ‘Applications and Case Studies’ part of the EDUCATE KB. The case study describes in detail the project, layout, construction, observations and performance of the buildings on the Jubilee Campus.

The field test

The first step of the Field Test consisted in the set-up of the phones and briefing of the participants. To minimise difficulties due to unfamiliarity with basic phone features and operation, students with an appropriate mobile phone were encouraged to use it for the field test. Four students did not have an appropriate phone (or elected not to use it), and in these cases Android phones and one tablet were provided (HTC Sense, Nexus One, Asus Transformer), with the EDUCATE on SITE app pre-installed. The students using their own Android mobile phone were asked to install the EDUCATE on SITE app (in most of the cases without problems). Students using Android phones received a short briefing on how to use the EDUCATE on SITE app, while students using non-Android phones received a short briefing on how to use the web version of the EDUCATE Portal via the mobile phone browser. Before commencing the field test, each participant was asked to ensure that they could access the EDUCATE Portal.

The 11 students were divided into three groups of three members, and one group of two members. Each group included at least one student equipped with an Android mobile phone, so that all students could have a look at the EDUCATE on SITE application, even if using the web version of the Portal and vice versa. The groups and associated mobile devices were as follows:

- **Group A**: iPhone 3Gs, HTC Sense (Android), Nexus One (Android);
- **Group B**: iPhone 4s, Blackberry 3G, HTC Sense (Android);
- **Group C**: iPhone 4, HTC Sense (Android) (plus an Asus Transformer Tablet);
- **Group D**: iPhone 3Gs, Sony-Ericsson Xpena (Android), HTC Sense (Android).

All participants were given a handout with a map (Figure 6) of the Jubilee Campus and a series of pre-set locations. To ensure that the users were effectively engaging with the subject matter and interacting with the software, each group of students was assigned a location identified on the map, and received a specific task that they had to investigate by consulting on their mobile device the information available on the EDUCATE Knowledge Base.
These tasks helped to guide the students through the field test and the use of the software. In addition, students were also asked to post a question on the EDUCATE Portal related to the specific task that they were assigned. The questions were answered in real time by the expert who had compiled the case study of the Jubilee Campus that the students were consulting.

The task that each group was asked to perform were as follows (Figure 7):

- **Group A: Location 1**: Reflect on the social sustainability of the Jubilee Campus, analysing the mixture of facilities available to support student life.
- **Group B: Location 2**: Look at the layout of the atria and analyse the ventilation system and strategies.
- **Group C: Location 3**: Look at the materials and construction methods employed in the main academic buildings, and reflect on the technological solutions applied.
- **Group D: Location 4**: Analyse the layout of the campus and reflect on orientation and landscaping.

No time limit was specified for the completion of the assigned tasks. During the field test, technical support was available in case of any problem with the browser, the app or the mobile phone itself.

Participants met after the conclusion of their tasks for an informal discussion that provided significant information. Following the collection of this informal feedback, a post-questionnaire was distributed to the students where specific questions on the development of the field test and the use of the EDUCATE Portal on a mobile device were posed.
The post-questionnaire

Table 2 summarises the most important results of the Post-questionnaire.

Table 2: Summary of results of the post-questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Field test users</th>
</tr>
</thead>
<tbody>
<tr>
<td>How did you access the EDUCATE Portal on your mobile device?</td>
<td></td>
</tr>
<tr>
<td>Website (online version of the EDUCATE Portal)</td>
<td>64%</td>
</tr>
<tr>
<td>App (EDUCATE on SITE)</td>
<td>36%</td>
</tr>
</tbody>
</table>

| Functionality of the Portal that should be made available on mobile devices: |                  |
| Knowledge Base                                                           | 91%              |
| Ask a Question                                                           | 100%             |
| EDUCATE on SITE Map                                                      | 67%              |

| Accessing the EDUCATE Portal via a mobile device is useful and should be extended | 100% |

<table>
<thead>
<tr>
<th>The app/website worked without problems on my device</th>
<th>Android App</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>I had difficulties with the mobile phone/tablet</td>
<td>67%</td>
<td>40%</td>
</tr>
<tr>
<td>The navigation and use of the app.website was intuitive</td>
<td>67%</td>
<td>90%</td>
</tr>
<tr>
<td>The app/website made good use of the device screen</td>
<td>83%</td>
<td>90%</td>
</tr>
<tr>
<td>The functionality of the app/website was sufficient</td>
<td>67%</td>
<td>90%</td>
</tr>
<tr>
<td>I found this app/website useful and would use it in future</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Did you use both versions</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Which did you prefer</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>I prefer the app on my mobile phone/tablet over the EDUCATE Portal website</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

Five of the 11 field test participants used both the website and the EDUCATE on SITE app. One group (Group C) was also provided with an Android tablet. The students with an Android phone were able to use the EDUCATE Portal also via the mobile web browser. In addition, the fact that each group of students contained at least one user with an Android device meant that all students were able to try out the EDUCATE on SITE app, either by watching while a group member used it or by borrowing the Android phone of another group member.

The responses of the participants to the post-questionnaire and in the informal feedback session were broadly positive. All participants found it useful to access the EDUCATE Portal via a mobile phone, and four of the five participants who tried both versions preferred the Android app over the EDUCATE Portal web version. All participants stated that they would use the EDUCATE Portal on a mobile device in future, suggesting that, even the app was still in prototype form, mobile access to the EDUCATE Portal was sufficiently compelling to ‘convince’ the two users who had previously stated the contrary within the pre-questionnaire.

Comparing the pre- and post-questionnaire results, it can be seen that the views of the participants regarding the functionality of the EDUCATE Portal that should be made available on mobile devices did not change considerably, although the number of users in favour of accessing the Knowledge Base on mobile devices decreased slightly. This can be explained by the fact that the screen on the mobile device was quite small and the data transmission took some time.

One of the users stated that they preferred to use the Knowledge Base on a desktop PC (bigger screen) and/or make a print out to make it easier to consult its contents. It was not possible to test the hypothesis that users prefer the Android app on mobile phones (small screen) and the EDUCATE Portal web version on Tablets (bigger screens) due to the low number of participants.

The field test also highlighted some issues with the current prototype implementation.

An interesting relationship can in fact be seen between the responses ‘the app/website worked well’ and the responses ‘I had difficulties with my phone/tablet’. Almost all users answered these two questions in the same way: the ones having problems with the app/web version had also problems with the phone/tablet OS. Another interesting observation is that almost all users were unable to distinguish between problems of the device OS and of the application. The fact that some of the participants using the app answered the part of the questionnaire relating to the web version and vice versa shows that some of the users even had problems distinguishing between device OS, application and browser-based Portal access. This tends to suggest that, in some cases, users were unable to resolve problems because they could not understand what caused the problem in the first place. Such problems were more apparent in those cases where the user was unfamiliar with the mobile device: participants using their own phones had fewer problems.
Although all the locations on Jubilee Campus used for the field test had more than satisfactory signal coverage – in some cases also backed up by the University wireless connection – one of the main problems was that the mobile devices were at times not connected properly to the internet or were automatically disconnected in order to save energy. The loss of the connection to the internet sometimes caused problems accessing content on the Android app. In many cases, the application was able to access cached content, although it was unable to load new information from the database of the EDUCATE Portal. Most of the users experiencing such problems thought that the app was faulty or not working properly.

Learning from OER

The results obtained in the context of this case study suggest that the rapid progress and mass diffusion of mobile technologies and devices provide significant opportunities for supporting situated and flexible forms of teaching and learning.

A mobile device-based approach to education – regardless of the disciplinary domain concerned – can offer several new functionalities in support of knowledge transfer (e.g. location-based services). Particularly when supported by customised software applications (apps), whose use is nowadays becoming very familiar to users of mobile phones and tablets, this offers the potential to allow students to embed learning in their daily life and access information instantly, on-site when it is required. In addition, a ‘mobile’ approach to learning can offer further methods of communication (SMS, instant messaging) that can enrich the learning experience.

Based on the results of the pre- and post-questionnaire, and on the feedback provided at the end of the field test, the two main advantages of a native application (app) over a web-browser-based access to an e-learning tool such as the EDUCATE Portal can be summarised as:

1. It is easier to address usability issues important for mobile devices with a small (smaller) screen. The ability to adjust content to the screen and to hide unneeded content and navigation elements was positively recognised by the field test users. A carefully designed application makes better use of the small screen of the phone, in comparison to a web-browser-based version. For example, the application can display only the navigation elements required for the specific task; the web-browser-based version displays additionally the browser navigation bar and, depending on the browser version, the address bar as well.

2. All native applications on Android (and iOS) devices have to use the same navigation concepts. Access to navigational elements always works in the same way, thus it is easy to learn how applications function. If users are familiar with the mobile device, it is quite easy for them to work with a new application. The web-browser-based version, however, needs some optimisation to adjust to small screens, and therefore must differ (at least to some extent) from the desktop-PC-based version. That is, the user can not completely reuse his/her learned knowledge gained by the use of the desktop PC version.

As shown by the results of this case study, it is important that these new forms of teaching and learning are supported by appropriate training of users (e.g. in the use of advanced technologies). However, their effective use and implementation emphasises the prospects offered by interactive pedagogical methods to foster a participatory approach in the training of new generations of students, supporting cross-referencing, deep learning and critical understanding of the topics presented in a curriculum, while providing the simultaneous acquisition of theoretical knowledge, the practice of empirical skills and the development of analytic capacities.
Conclusions

Nowadays, students can be considered ‘digital natives’, demonstrating fluency and familiarity with e-learning environments. These new forms of flexible and responsive teaching and learning have been proven to establish new ways for students to learn, to work and collaborate with their tutors and peers, locally and globally, to facilitate interchange of knowledge between multidisciplinary domains and provide easy and open access to information and educational materials at any time, from anywhere.

Nevertheless, in education for sustainable environmental design – as in every other pedagogical field – e-learning should by no means be considered as a substitute for traditional lectures or studio-based activities, due to the risk that students could solely rely on the most basic visualisation, search and learning tools, without developing the necessary reflective competence necessary to relate theoretical principles with evidence-based information and insightful appreciation of the topic at hand (Altomonte, 2010).

Yet, by enabling some educational activities to take place outside the physical boundaries of the academic environment, the effectiveness of the pedagogy can benefit in relation to engagement of students in learning and enhanced motivation through interactive resources.

References


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