PerZoovasive: contextual pervasive QR codes as tool to provide an adaptive learning support

José Rouillard
Laboratoire LIFL - Université de Lille 1
59655 Villeneuve d’Ascq Cedex
France
jose.rouillard@univ-lille1.fr

Mona Laroussi
Laboratoire LIFL - Université de Lille 1
59655 Villeneuve d’Ascq Cedex
France
mona.laroussi@univ-lille1.fr

ABSTRACT
This paper presents an adaptive pervasive learning environment, based on contextual QR Codes, where information is presented to learner at the appropriate time and place, and according to a particular task.

This Learning environment is called PerZoovasive, where learning activities take place in a zoo and are meant to enhance classroom activities.

This paper discusses adaptivity and context awareness system as strategies to provide support for learners in mobile pervasive situations. How to adapt the information while taking into consideration the context of the student or the group? Do context-awareness applications affect information proposed to users? Which role can be played by QR Codes in a pervasive environment? Can this experimentation be used in other learning situations?

Categories and Subject Descriptors
J.11 [Computer Applications]: Administrative Data Processing

General Terms
Design, Experimentation, Human Factors.

Keywords
Ubiquitous Computing and M-Learning, Context Management, Human Computer Interaction (HCI) for M-Learning, Contextual QR Codes.

1. INTRODUCTION
For several years, we have seen the miniaturization of electronic devices and their integration into everyday life. Mobile phones are almost all equipped with high quality camera, diverse connections to different networks (WiFi, GPRS...), "free hand" features, etc. With numerous kinds of personal assistants (PDA) that use GPS, users can be helped and vocally guided to follow a specific route. This trend that consists of systematically digitalizing resources and enabling access to data needed anywhere and in anytime is sometimes called, in the literature, ubiquitous. However, there is a wide variety of terms used to describe this paradigm that is opposed to the more conventional desktop metaphor -one computer per person-.

This is known as ambient intelligence, ubiquitous and pervasive computing. This refers to the increasing use of widespread processors that exchange rapid and brief communications with each other and with sensors. Thanks to their much smaller size, these sensors will be integrated into everyday objects, until they become almost invisible to users.

Indeed, as Mark Weiser explains: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." [16], [17]. He gives here a first definition of pervasive computing.

Pervasive computing refers to the ability to access the same service through various channels of communication, such as a desktop computer, a PDA or even a phone to use voice, phone keypad (DTMF) or SMS, depending on the needs and constraints of the user. Adam Greenfield, meanwhile, uses the word "Everyware". This word, formed from "everywhere" and "hard/software" is a neologism to encompass the terms of ubiquitous computing, pervasive computing, ambient computing and tangible media. He explains in more details his thought: "When I talk about surfacing information that has always been latent in our lives, I mean putting precise numerical values on one present location, on what task we might happen to be currently engaged in, and in whose company; even on things like daily caloric intake or voice stress or urine chemistry. I mean making those values broadly accessible. I mean permitting operations to be performed on such values or aggregations of same, such that algorithmic guidance and control can be installed." [5].

"Everyware" can be exploited in different manner. It can be a way to broadcast advertising or to communicate in a social network. In our work, we use the notion of "Everyware" to adapt a learning environment to students. To test the feasibility of our project, we use as example a complementary course done in a zoo; Being in a museum or zoo and receiving dense information not adapted to level or language is a problem users frequently
face. This situation is not comfortable and usually the visitor’s objective is not reached.

In the domain of object identification, different kinds of codes and technologies are used in order to store, retrieve and manage information. We choose to use 2D barcodes for the following reasons:

First, the usage of RFID\(^1\) or NFC\(^2\) solutions requires devices equipped with special hardware reader. Oppositely, with barcode technology, optical solutions are usable. Almost all the phone and devices embedding a good quality digital camera are able to use it.

Second, this basic technology is cheaper than other solutions in which chips must be used to store and retrieve data. Modifying data in RFID chips needs an appropriate material. For the administrator of our system, changing a code is easy as printing a sheet of paper representing the 2D barcode.

Lastly, compared to 1D barcodes, 2D barcodes have a higher storage capacity\(^3\) and much more various type of information can be encoded instead of only a few digits (13 digits for example in EAN - European Article Numbering - barcode). Moreover, QR Codes comes with four error correction levels able to retrieve damaged code (Level L: 7% of codewords can be restored, Level M: 15%, Level Q: 25% and Level H: 30%).

We present in this paper an adaptive pervasive learning environment, based on contextual QR (Quick Response) Codes, where information is presented to the learner at the appropriate time and place, and according to a particular task. We discuss the adaptivity and context awareness system as strategies to provide support for the learner in mobile pervasive situations.

This document is structured as follows: Section two presents and explains the background and motivation of this project. Section three gives an overview of the pervasive system, from the pedagogical and technical point of view. Applications scenarios are given in this section before a conclusion and some ideas for future work.

2. MOTIVATION AND BACKGROUND

Our scientific research is driven by simple questions that often lead to complex answers. For example, our works are possible solutions to questions such as the following: How to provide students with adaptive information in a pervasive learning environment? How to adapt the information taking into account the context of the student or the group? Do context-aware applications have a real effect on information proposed to users? Which role can be played by QR Codes in pervasive environment?

2.1 The p-LearNet project

We are involved in research on new interactive systems for ubiquitous e-Learning within the p-LearNet project\(^[12]\) which is supported by the ANR (Agence Nationale de la Recherche Française - National French Research Agency); p-LearNet means Pervasive Learning Networks. It’s an exploratory project on adaptative services and usages for human learning in the context of pervasive communications.

The main goal of this project is to explore the potential of ubiquitous and pervasive communications, over heterogeneous networks, for a large and important field of application: human learning. To achieve this, we take into account the maximum available information including places, times, organisational and technological contexts, individual and/or collective learning processes, etc.

2.2 Mobile learning

We consider Mobile learning a way to learn through mobile computational devices: Palms, Windows CE machines, even digital cell phones.

The vision of mobile computing is that of portable computation with rich interactivity, total connectivity, and powerful processing. This small device is always networked, allowing easy input through pens and/or speech or even a keyboard when necessary, and the ability to see high resolution images and hear high quality sound.

Mobile learning can be considered from two viewpoints. The first one is a technically oriented perspective regarding traditional behaviorist educational paradigms as given and tries to represent or support them with mobile technologies. A main concern from this perspective is how to create, enrich, distribute and display learning material on mobile devices; the main benefits are to personalize the way of learning (where you want, when you want, what you want, as fast as you want, how you want, etc.)\(^[8]\).

The second, learning is not only the simple use of mobile devices for pedagogical purposes; even if this mobility favors the distant learner, but it gives a broader definition of mobility. It is interested in continuous connectivity (anytime and anywhere), and explores the dynamic correlation between wire and wireless devices (where the tasks distribution is based on performances), people (intense interactions) and their environment (powerful support for effective learning).

Mobile learning allows learners to access learning material related applications anytime and anywhere through several devices helped by the notion of context and context-aware.

2.3 Context

In literature we found many definitions of context\(^[3],[7],[1],[2],[9],[14]\). In a previous paper\(^[10]\), we exposed all definitions, common and divergent points of context and also give our own definition. Context is defined as: “a set of element that we consider appropriate to interaction between the user and the application.”

Given the diversity of context information, it is useful to attempt to categorize it to make it easier to comprehend in a systematic manner. For this paper, we introduce a simple classification of context information, based on categories of contextual information.

We introduce two essential categories of context information — individual context and shared context\(^[10]\).

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\(^1\) RFID: Radio-Frequency IDentification

\(^2\) NFC: Near Field Communication

\(^3\) Numeric: max. 7,089 characters; Alphanumeric: 4,296; Binary (8 bits): 2,953 bytes; Kanji/Kana: 1,817 characters.
Individual context includes information relevant to the interaction between the learner and m-learning applications. Shared context includes information relevant to collaborative group work or learners sharing common interests. Individual context can be viewed as specific to each learner. Shared context is more related to collaborative work (see Figure 1).

Communication, coordination and production are results of collaboration in shared context environments where each learner is an actor and each learning situation has his own context.

Shared context can be differently perceived by students and can so influence in numerous ways the individual context.

2.3.1 Context-aware
We define the context-aware by identifying the following features of context-aware applications:
- Ability to acquire the current context;
- Ability to interpret the current context;
- Ability to model context;
- Ability to store context in order to construct a context history and to predict or anticipate future context;
- Ability to make it possible to share experiences with other learners based upon specific (context) information
- Ability to reason about context for deducing new contexts;
- Ability to filter context;
- Ability to adapt the behavior of Mobile learning application to meet the dynamically changing contextual requirements. This adaptation includes content adaptation and presentation adaptation;
- Ability to adapt context for creating a favorable learning environment.

We can find in the literature a relative close approach from our, with other work around the notion of context kernel:

“Applications are usually supported by software infrastructures for context management (see Context Toolkit, Context Fabric, GaiaOS). When designing such infrastructures, designers must take into account support for several levels of heterogeneity, openness, communication efficiency, loose coupling, and asynchrony. An alternative to deal with these issues is to take advantage of the benefits provided by Web Services.”[6].

2.3.2 Contextual QR Codes
A QR Code is a two-dimensional barcode introduced by the Japanese company Denso-Wave in 1994. This kind of barcode was initially used for tracking inventory in vehicle parts manufacturing and is now used in a variety of industries. QR stands for “Quick Response” as the creator intended the code to allow its contents to be decoded at high speed. In Japan, some teachers are using QR codes to distribute resources to students [4].

The notion of contextual QR Codes was proposed in previous recent work [13]. It can be defined as the following: it’s the result of a fusion between a public part of information (QR Code) and a private part of information (the context) provided by the device that scanned the code. Figure 2 shows the public and private parts of a contextual QR Code.

The private part can be one or more of the following user’s profile, current task, device, location, time and environment of the interaction. The mobile device decodes the QR Code and merges it with private data obtained during the interaction. Then, the XML (Extensible Markup Language) resulting file is sent to a web service (created in our laboratory) that computes the code and returns personalized messages.

Some private information can be stored in the owner’s profile of the phone (the class level for example) and some others are given directly by the user when the interaction takes place (language, class or exam, etc.).
3. PERZOOVASIVE SYSTEM
A previous study of people engaged in a location-based experience at the London zoo was reported by O’Hara and colleagues. In this experience, location-based content was collected and triggered using mobile camera phones to read 2D barcodes on signs located at particular animal enclosures around the zoo. “Each sign had an enticing caption and a data matrix code (approx. 7x7 cm) which encoded the file locations for the relevant media files.” [11].

By capturing a 2D barcode, participants extracted the file’s URIs from the codes and added the corresponding preloaded content files (audio video and text) into their user’s collection.

The fundamental distinction between that approach and our system is that the London zoo system provides always the same content to the user, while the perZoovasive system provides information according to a particular context.

We’ll now present the system functionalities through the following scenario.

3.1 Pedagogical scenario
A French elementary school decides to organize a visit to the zoo. This visit allows a follow-up of the pupil’s educational curriculum. The issue is the different levels of pupils and number of teachers accompanying them. The teachers do not usually have a good knowledge of the subject. Do we have to display, disseminate, and post the same information to all pupils? How to make sure each group of students gets the appropriate information.

The accompanying teacher usually has a cellular phone. We propose to use the phone to provide adapted information. When the group gets to the zoo, each teacher’s cellular phone connects to a dedicated server and useful softwares are set up. For instance, Mrs Martin is preparing a visit to a zoo for her CE1 class. She thinks it is a good idea to establish a link between the lesson that she gave in her classroom during the morning, about the animals and their environments, and the real world (see Freinet’s pedagogical method). She starts her visit with her group and stops in front of the Gibbons’ cage. She takes a photo of the QR code stuck to the cage.

This image is automatically sent to the server. Instantly, a French text adapted to the pupils’ level and describing the Gibbon is then displayed on her phone. The pupils then can listen to a synthesized voice deliver the information on Mrs Martin’s mobile cellphone.

At the same time, another class from an English school stops in front of the same cage. Mr Ford, the teacher of this class (a Grade 2 in French elementary school (CP, CE1, CE2, CM1, CM2)).
different level than the French one) is doing the same operation as Mrs Martin with his mobile phone.

The presented text is adapted to the level, the language and the task of these pupils. The two groups continue their visit and the same thing happens again in front of each different cage.

### 3.2 Technical scenario

Figure 3 presents a mobile application, called perZoovasive, developed in our laboratory. It was written in C# language and runs, thanks to Tasman library [15], on a smartphone HTC TyTN II (Kaiser) supporting Windows Mobile 6.

The name of the user and the level of the class are automatically detected in the mobile registry (ControlPanel\Owner). The user clicks on the upper left radio button if the task is a lesson or on the upper right radio button if the task is a Quiz knowledge control.

In addition to the plain text, it is also possible to choose the flag corresponding to the appropriate language, and to select (or not) the TTS option in order to obtain a Text-To-Speech response.

The trace option is a debug tool that shows the XML sent and received data. The camera manager is invoked by clicking on the “Capture QRCode” button. Then, according to the selected representation (each cage number is coded with a particular QR Code), the decoded information is presented to the user. The application becomes extremely context-aware by using a combination of many parameters.

![Figure 3](image1.png)

**Figure 3:** Example of generated text (cage=123, level=CM2, language=French, task=lesson)

The web service that receives the contextual QR Code (a merge of public and private data) opens a file which has the following canonical form: Cage_Level_Language_Task.txt. For example, the file named “8245_CM1_FR_Quiz.txt” is related to a Quiz in French, for the CM1 class (level 3) and for the cage number 8245.

On Figure 3, since the teacher does not select the TTS option, she can read the data provided by the system on her mobile screen and give the information to her pupils as she sees it.

![Figure 4](image2.png)

**Figure 4:** A teacher is scanning a Contextual QR Code to retrieve information about gibbons.

Figure 4 shows a French-talking teacher in a zoo, using the PerZoovasive application with a 3G connection (provided by Orange France) and scanning a contextual QR Code in order to obtain information about gibbons. After a few seconds, she can read her mobile screen and give relevant information about this animal to her pupils.

![Figure 5](image3.png)

**Figure 5:** A teacher is scanning a Contextual QR Code to retrieve information about turtles.

On Figure 5, we can see the same teacher asking information about the turtle of this cage. She could retrieve general
information about this kind of animal (species, origin, speed, food…) but also personal data about that particular turtle (name, age, birthday, parents, etc.).

From a pedagogical point of view, the teacher decides whether or not (by checking a box on her mobile interface) to get a synthesized speech of the text provided by the system. Of course, it would take a few more seconds to be calculated.

Technically, the fusion of the private part of the message (such as the level or the chosen language, for instance) and the public part of the message, represented by data captured during the interaction (such as the number of the cage, for example) is sent to a web service able to manage the provided information. Finally, the user receives on his mobile appliance the result of the interpretation of the contextualized QR Code.

We have shown that contextual QR Codes can be easily integrated into pervasive and ubiquitous applications and we believe that the power of Quick Response Codes coupled with context-aware information will provide an important impact on Human Computer Interaction.

This experimentation can be extended to other case studies such as museum, trip, etc. Finally, we will study the impact of adaptativity on learner understanding and note the results.

5. ACKNOWLEDGMENTS

We are grateful to ANR P-LearNet project for providing support for this research, to Tasman, QuickMark, Eric Metois (Eym barcode SDK) and Orange France (3G) for the special tools provided.

6. REFERENCES


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