DESIGNING TOOLS FOR CONTEXT-AWARE ADAPTIVE MOBILE LEARNING

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Abstract

During the past years, ubiquitous computing has influenced Technology-enhanced Learning. This is widely known as ubiquitous learning. On the other hand, the widespread ownership of mobile devices has lead to an increased interest to ubiquitous learning that is supported by mobile devices. This is commonly referred to as mobile learning. An important success factor for ubiquitous and mobile learning is the pedagogically meaningful and technically feasible process of learners’ contextual information. While the formal definition of context is still an open issue, contextual information in Technology-enhanced Learning involves information that characterizes a learners’ given situation. Thus, in order to achieve personalized and ubiquitous learning, tools for context-aware adaptive learning designs (authoring tools) and context-aware adaptive delivery of learning activities (run-time tools) are needed. In this paper, we target addressing this issue, that is, we describe a set of tools that incorporate a context-aware content adaptation mechanism at both the learning design and mobile delivery process.

Keywords: Mobile learning, Context-Aware Adaptive Learning, IMS Learning Design Authoring Tool, Learning Activities Mobile Delivery Tool.

1 INTRODUCTION

During the past years, ubiquitous computing, namely, the seamless integration of systems and environments in daily activities has influenced Technology-enhanced Learning (TeL) (Sakamura and Koshizuka, 2005). This has initiated a new trend in TeL, which is widely known as ubiquitous learning and it is defined as: “the potential of computer technology to make learning possible at any time and at any place” (Hwang, 2006, p. 1). Ubiquitous learning can offer important benefits to learners, which could be summarized as follows (Abarca et. al, 2006; Ogata and Yano, 2004):

- Supports pedagogical models that are based on authentic learning by exploiting real-life context
- Provides flexible, adaptive and personalized learning experiences by exploiting learners’ contextual information

On the other hand, the widespread ownership of mobile devices has lead to an increased interest to ubiquitous learning that is supported by a wide range of mobile devices. This is commonly referred to as mobile learning and can be treated as part of ubiquitous learning. Thus, mobile learning (m-learning) is defined as: “the process of learning and teaching occurs with the use of mobile devices anywhere (context aspects) and anytime (device aspects)” (Traxler, 2009; Kukulska-Hulme, 2009). An important success factor for ubiquitous and mobile learning is the pedagogically meaningful and
technically feasible process of learners’ contextual information. While the formal definition of context is still an open issue, contextual information in TeL involves the information that characterizes a learners’ given situation (Luckin, 2010). Thus, in order to achieve personalized and ubiquitous learning, tools for context-aware adaptive learning designs (authoring tools) and context-aware adaptive delivery of learning activities (run-time tools) are needed.

Despite all that, digital educational resources are mainly designed assuming access and delivery through desktop computers, increasing the barriers of learners in accessing them through their mobile devices. Within this framework, it is important to consider adaptation mechanisms of educational resources based on learners’ context characteristics that can be integrated into the learning design process and enable semi-automatic delivery of educational resources appropriately adapted to learners’ mobile devices. In this paper, we aim to address this issue by describing a set of tools that incorporate a context-aware content adaptation mechanism at both the learning design and mobile delivery process.

The paper is organized as follows. Following this introduction, section 2 discusses the concept of context in mobile learning and identifies its main characteristics. Section 3 presents the mobile content adaptation mechanisms. Section 4, presents the description of a learning design authoring tool and a learning design mobile player, which incorporate context-aware content adaptation. Finally, we discuss main conclusions and ideas for further work.

2 CONTEXTUAL INFORMATION IN M-LEARNING

A commonly used definition of context in computer science is: “any information that can be used to characterize the situation of an entity participating in the interaction between a user and a system” (Dey and Abowd, 2000, pp. 3–4). In the field of technology-enhanced learning, there are a number of attempts to model context so as to describe the elements that could participate in learner’s interaction with learning systems (Baldauf et. al, 2007; Schmidt, 2005). In m-learning, the context has been proposed to be modelled into two parts: one related to the learning design and another related to the mobile environment in which learners interact by completing learning activities (Pachler, Bachmair and Cook, 2010). These two categories are referred to as learning context and mobile context (Siadaty et. al, 2008).

Learning context can be described by the elements of a learning design (see Table 1). A learning design is defined as:

“the description of the teaching-learning process, which follows a specific pedagogical model or practice that takes place in a unit of learning (e.g., a course, a learning activity or any other designed learning event) towards addressing specific learning objectives, for a specific target group in a specific context or subject domain ” (Koper and Olivier, 2004, p. 2).

Mobile context can be referred to as contextual information such as people, technological artifacts, learner’s location and its physical conditions, available time, etc., which can be captured by hardware, measured by sensors or even entered by the learner. We are considering a classification of the mobile context characteristics with eight dimensions (see Table 1) based on characteristics defined by mobile context-related research works (Kukulska-Hulme, 2009; Siadaty et. al, 2008; Christopoulou, 2008).
### Table 1. Learning and Mobile context characteristics

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning design</td>
<td>learning objectives, pedagogical models, learning activities, participating roles, tools and resources</td>
</tr>
<tr>
<td>Learner</td>
<td>competence profile (knowledge, skills, attitudes), role, semi-permanent personal characteristics (learning style, learning needs and interests, physical or other disabilities, etc.).</td>
</tr>
<tr>
<td>Mobile context</td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>temporal personal information (mood, preferences, needs, interests, etc.).</td>
</tr>
<tr>
<td>People</td>
<td>role, relationship, contributions and constraints.</td>
</tr>
<tr>
<td>Place</td>
<td>location, zones, interactive space, cultural background and learning setting.</td>
</tr>
<tr>
<td>Artifact</td>
<td>technological: physical properties and digital properties, and non-technological.</td>
</tr>
<tr>
<td>Time</td>
<td>task duration, task scheduled, action happens, availability.</td>
</tr>
<tr>
<td>Physical conditions</td>
<td>illumination, noise level, weather conditions, etc.</td>
</tr>
</tbody>
</table>

### 3 Mobile Content Adaptation

In technology-enhanced learning, a great amount of digital educational resources (e.g. images, audios, videos, web contents, etc.) and tools (e.g. course management systems, collaborative tools, e-portfolios, social network services, etc.) have been developed to facilitate enhanced learning experiences. However, most of these resources and tools have been developed assuming the desktop PC as the delivery end. In m-learning environments, providing those kinds of resources and tools while taking into account the limitations of mobile devices (such as limited screen sizes, limited memory available for page rendering and limited types of content supported (W3C Mobile Web Best Practices, 2008)) is a challenge. Thus, the problem is twofold: how to ensure seamless access to resources, tools and services taking into consideration the end device (i.e. mobile devices) and how to exploit the possibilities of the devices in providing context-aware adaptive learning experiences. To this end, in this paper we discuss educational resources adaptation mechanisms for context-aware selection and/or automatic transformation for delivery within learning activities that are executed via mobile devices.

According to Bomsdorf (2005) mobile content adaptation commonly consists of content filtering, application filtering, polymorphic presentation and content classification. In our work, we consider the processes of content filtering and polymorphic presentation, through educational resources transformation, as adaptation mechanisms to our approach.

#### 3.1 Appropriate Educational Resources Selection

During the process of learning design, the structured flow of learning activities populated with resources and facilitated by certain tools and devices, where teachers and students participate assuming certain roles is described (Griffiths et al., 2005). Furthermore, adaptation rules and conditions can be added at the design process, so as to customize learning plans to individual needs and conditions (Towle and Halm, 2005; Berlanga and García, 2005).

A standard notation language for the description of learning designs is the IMS Learning Design (LD) Specification (IMS Global Learning Consortium, 2003). In IMS-LD, a learning design can be built at three different levels (level A, level B and level C). At level A, learning designs include: a series of
learning activities, performed by one or more actors/roles, in an environment consisting of learning objects or services. Level B adds properties (storing information about a person or group), and conditions (placing constraints upon flow) and level C adds notifications that can facilitate reconfiguring design based on run-time events (Koper and Burgos, 2005). In our work, educational resources selection consists of taking decisions based on IMS-LD Level B conditions that take into consideration mobile context characteristics.

3.2 Educational Resources Transformation

A transforming process consists of a set of steps to transcode the properties (format, type, size dimensions, quality, etc.) of one or more resource elements by considering the technical capabilities of the user's device (i.e. browser, network connection, display, media support, etc.). In our work, the educational resources transformation consists of content transcoding/recoding processes that allow customizing the file format or the properties of the educational resources according to different parameters based on the delivery device capabilities.

The transforming process we adopt takes place at two levels: (a) at design-time level and (b) at run-time level, and each time consists of three phases. At design-time one phase describes the authoring of a learning design (using properties and conditions) and at run-time the detection of the context information. The other two phases describe a dynamic transformation where educational resource transformation occurs and adapted learning designs are generated referencing the transformed resource. Figure 1 and Figure 2 present the educational resources transforming process at design time and at run-time, which has been presented in details in previous work reported in (Gómez and Fabregat, 2010).

![Figure 2. Transforming process at design time (Gómez and Fabregat, 2010)](image1)

![Figure 3. Transforming process at run-time (Gómez and Fabregat, 2010)](image2)
4  **TOOLS FOR CONTEXT-AWARE LEARNING DESIGN AND MOBILE DELIVERY**

In this section, we present design requirements for (a) an IMS-LD authoring tool that facilitates authoring of learning designs that incorporate context-aware adaptive resources selection, and (b) an IMS-LD mobile player that facilitates context-aware delivery of learning designs with content adaptation features.

4.1  **Authoring Context-aware Learning Designs**

The design requirements of an IMS-LD authoring tool for learning designs that incorporate context-aware adaptive resources selection could be summarized as follows:

- **Requirement 1**: The user should be able to define appropriate content adaptation rules according to the different values of the mobile context characteristics (as defined in Section 2) for the entire learning design. These rules should be inherited by all the learning activities, which constitute the learning design. This functionality aims to reduce the effort for defining rules.

- **Requirement 2**: The user should be able to define context-aware content adaptation rules for each individual learning activity that a learning design incorporates. This is necessary, since the resources of an individual learning activity may need to be adapted based on different adaptation rules from those defined for the entire learning design, when specific contextual information is detected. This functionality aims to enhance flexibility for defining adaptation rules.

- **Requirement 3**: The user should be able to create profiles of content adaptation rules (for certain values of mobile context characteristics), which can be used during the authoring process of a new learning design. This requirement enables end-users to reuse profiles of content adaptation rules among different learning designs.

- **Requirement 4**: The tool should have the capability to automatically transform the content adaptation rules inserted by the user to IMS LD properties and conditions and save this information to the produced IMS LD XML manifest, which is exported by the tool. This requirement is very important because it makes this process accessible to non-XML experienced users.

- **Requirement 5**: The user should be able to graphically design learning designs based on the interconnection of user-defined learning activities. This requirement is making the learning design process efficient and user-friendly.

- **Requirement 6**: The tool should provide the capability to directly assign educational resources to the learning activities of the learning design. This should be facilitated by providing access to Learning Objects Repositories (McGreal, 2004), with recommendations facilities about the appropriate available educational resources for a given learning activity, based on metadata descriptions. This requirement is essential for reducing costs and efforts in selecting educational resources.

An initial development of the aforementioned requirements is in progress by customizing an existing IMS LD authoring tool, namely the ASK-Learning Designer Toolkit (ASK-LDT) (Sampson, Karampiperis and Zervas 2005).

4.2  **Delivering Context-aware Learning Designs**

The design requirements of an IMS-LD mobile player for context-aware learning designs with content adaptation features could be summarized as follows:

- **Requirement 1**: The tool should be able to automatically detect contextual information such as, place, time, and in some cases physical conditions according to the user situation and it should be able also to let the user input contextual information that it is not possible to be detected automatically. This is an essential requirement so that the learner’s current situation can be fully detected and recorded by the tool.

- **Requirement 2**: The tool should be able to import learning designs compatible with IMS LD and this process should be facilitated by providing to the user access to Learning Design Repositories (Paquette et. al, 2006; Sampson et. al, 2011), where the user can search and find appropriate
learning designs according to his/her needs and preferences. This requirement is making the process of selecting learning designs more flexible for the end-users of the tool.

- **Requirement 3**: The tool should be able to handle the adaptation rules of the delivered learning design and match them with the values of contextual information automatically detected or provided by the user, so as to enable the content adaptation mechanism (described in section 3) and deliver adapted educational resources according to the type of user’s mobile device. This is an important requirement for providing to the users with valid content adaptations.

- **Requirement 4**: The tool should be client-side, so it can be installed to the mobile device and no internet connection should be required during the execution of learning activities. Internet connection should be required only during the content adaptation process, when the tool should communicate with the content adaptation mechanism located on a server. This requirement is important because mobile devices are not constantly connected to the internet and the user should be able to execute the learning activities even if he/she is not connected to the internet.

- **Requirement 5**: The user should be able to view the graphical structure of the learning activities that a learning design incorporates and navigate to these learning activities. This requirement is making navigation to learning activities more usable to end-users.

An initial development of the aforementioned requirements is in progress by customizing an existing IMS LD player, namely the ASK LD-Mobile-Player (Sampson, Götze and Zervas, 2007).

### 5 Conclusions and Future Work

An important factor for achieving meaningful learning experiences with ubiquitous and mobile learning is the capability of capturing and processing learner’s contextual information. This is an emerging issue since digital educational resources are mainly designed assuming access and delivery through desktop computers, and, moreover, contextual information can facilitate the development of content adaptation mechanisms for delivery of educational resources to learners’ mobile devices.

In this paper, we discussed the concept of context, we identify its characteristics focusing on the mobile context characteristics and we presented a content adaptation mechanism, which takes into account contextual information to perform adaptations to educational resources. Finally, we presented design requirements for a set of tools that incorporate this context-aware content adaptation mechanism at both the learning design and mobile delivery process. This is an essential step for the development of such tools that can support truly personalized and ubiquitous learning.

Future work includes: (a) the implementation of the tools that were designed in this paper (b) the further implementation of our adaptation approach towards adapting learning activities (not only educational resources) taking into account contextual information.

### References


