COMPARATIVE STUDY OF THE CONTEXT-AWARE ADAPTIVE M-LEARNING SYSTEMS

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ABSTRACT

In technology-enhanced learning (Tel), the use of mobile applications is increasing, which improves learning experiences, allowing learners to carry out daily activities anytime and anywhere. However learners might lose interest and motivation to learn using their mobile devices if content adaptation and learning personalization processes are not appropriately designed. This has led to an increasing interest on context-aware adaptive and personalized mobile learning systems aiming to provide learning experiences delivered via mobile devices and tailored to learner's personal characteristics and situation, increasing user satisfaction and facilitating learning achievement. This paper includes the detailed survey about context aware and adaptive m-learning, which serves as the base for new researches in this area.

KEYWORDS

Context-Aware Adaptive, Personalized Mobile Learning Systems, Educational Needs

1. INTRODUCTION

The rapid development of emerging technologies for mobile devices has enabled them to contribute strongly to the creation of new paths for learning; it has drawn the attention of researchers in Technology-enhanced Learning (TeL). They have been interested in investigating how these technologies can be exploited for educational purposes aiming to enhance learning experiences. As a result, this has lead to a research trend which is commonly referred to as Mobile Learning (ML). Context-aware learning has recently got attention of many researchers. It will be a key area for m-learning in the oncoming years because it is moving beyond content delivering in place and it is getting involved with issues surrounding how information from context can be retrieved, stored, represented so as to support tools and services be delivered in optimal ways (Madhubala.R and Akila 2017; Gómez 2013) .

Before this work, many surveys have been conducted on context aware mobile learning systems with diverse perspectives (Baccari, 2015; Hassanov 2017), however, these works reveal two major shortcomings: one is the lack of published surveys on this topic and their missing extension & comprehensiveness since many of them are outdated and do not include newer proposals. The other shortcoming is that there has not been a recent study which would thoroughly analyze contemporary learning environments from the perspective of the two main issues in the design of context-aware adaptive and personalized mobile learning systems, namely, the learner's contextual information that influence adaptations, and the type of adaptations that can be performed based on retrieved learners contextual.

2. BASIC CONCEPT

2.1 Learner's Contextual Information

In this paper, we use the definition of context as a set of entities that constitute the learner's situation:

- Learning context: Includes:
  - **Learning Design**: Learning objectives, pedagogical strategy, learning activities and Resources
  - **Learner profile:** Competence profile (Knowledge, skills, attitudes) role

- Mobile context: Includes Learner temporal information (mood, needs, interest…), People (relationship, role...), Place, Artifact (Technological and non-technological), Time and Physical conditions (noise, illumination…) (Gómez, 2012).

2.2 Type Adaptation

We can identify two main categories of adaptation in context-aware m learning systems: (a) Adaptations related to Educational Resources and (b) Adaptations related to Learning Activities (Gómez. S, 2013):

a. Adaptation of Educational Resources:
- Selection: This type deals with selecting appropriate educational resources and presenting them to the learners based on different learners' contextual elements.
- Presentation: This type considers that educational resources are adaptively structured for access via mobile devices by taking into account parameters related with the learners' type of mobile device, the learner's profile, location, physical conditions

b. Types of adaptations related to Learning Activities:
- General Adaptation: This type of adaptation deals with automatic generation of individual learning activities based on contextual information (Gómez, 2016; Soualah-Alila, 2014; Harchay, 2015).
- Feedback and Support (scaffolding): This type of adaptation includes personalized hints at the right time and suggestion of suitable learning activities depending on different criteria derived from learner's contextual elements (Gómez, 2014).
- Navigation to locations: This type of adaptation includes mostly location-awareness and planning of suitable learning activities in real-world (Hsu, 2015).
- Communication and interaction: Used for finding peers based on their location with whom they can meet virtually, build learning groups and share knowledge or experts with whom they can communicate for asking advice (Gómez. S, 2013)

3. METHOLOGY

3.1 Search Criteria

First, we defined literature search criteria as follows:
- A combination of predefined keywords (e.g., personalized mobile learning systems, context-aware systems, context aware mobile learning);
- Publication time range 2010-2017;
- Type of papers: conference and journal publications;
- Digital libraries/search tools: Google Scholar, Research gate, Freefullpdf, SNDL.

3.2 Classification Criteria

Before the presentation of the overview, we define in this section the criteria of the classification:
- Context acquisition Taxonomy: Sensor (S), Derived (D) and User input (IU).
- Context modeling Taxonomy: There are several popular context-modeling techniques: Key-value, Markup scheme, and Graphical, Object-based, Logic-based, Ontology and Database based models Context entities Taxonomy: previously listed.
- Sensors: We identified six groups of sensors that have been used as sources for context data: RFID/NFC, GPS, Camera, Microphone, IR (infrared)-based sensors, and network (e.g., bandwidth)
- Mobile devices: PDA Smartphone, Tablet
- Adaptation strategy: explained in section 2.

4. OVERVIEW

Here we present an overview of the context aware learning environments. We have focused on two main issues namely, the learner's contextual information that influence adaptations, as shown in table 1.

Table 1. Overview of Context-Aware Learning Environments

System	Description
Gomez et al. (2016)	Delivers contextualized content to the students in nursery, medicine and systems engineering
Gomez et al. (2014)	Supports semi-automatic adaptation of learning activities, particularly for learning English
Hsu et al. (2016)	Able to actively provide the required learning support to individual students when they approach the corresponding real-world learning targets (Museum).
Sevkli et al. (2017)	Leverages the pervasive nature of mobile computing and utilizes context-aware mobile application features to encourage and promote Hadith learning in daily life.
Soualah et al. (2014)	Presents a general architecture that aims to offer a new approach for designing and recommending learning contents as part of industrial training.
Marcelo (2016)	Context4Learning is a mobile application used in educational program based on cloud computing and LMS (Moodle),
Harchay et al 2015	Semantic web-based system that supports personalized self-assessment in mobile environments for computer science students

5. ANALYSIS AND DISCUSSION

We can infer from the results presented in Table 2 that is the most popular clients of the context aware mobile learning environment are PDAs. Their popularity exceeds that of Smartphone, this is probably due to their integration of RFID and NFC reader modules, which made them smart in terms of sensing capabilities.

Location as one of the context dimensions is present in the reviewed contributions that give more attention to the location awareness in the mobile learning systems. In such systems, it is essential that the learning environment can adapt its behavior to match the learner's location by the use of Sensors. The popularity of Location awareness is aligned with the popularity the Spatio-temporal context entity group.

We can also notice from the table that Input user (IU) and Sensors (S) are the most used between the context acquisition methods.

Ontology is the most popular between contexts modeling approaches. Ontology is a very promising instrument for modeling contextual information due to their high and formal expressiveness. We expect that ontology will keep their dominant place as a context modeling approach in context-aware learning environments, although novel approaches based on machine learning are likely to emerge in the future.

In the other hand, it is remarkable that the most used adaptation strategy is the general adaptation, it focuses on not only one specific adaptation aspect but on a general learning process, moreover we can also find out that there is no contribution based completely on the communication and interaction strategy, This type of adaptation helps learners to Find peers based on their location. According to our interpretation, the reason for this is that most context aware learning environments are not developed to be used in closed spaces (classrooms, laboratory...). In fact they represent informal learning environments located beyond the physical space boundaries, in contrary to the principle of communication and interaction adaptation strategy that promotes collaboration between close learners. However as said before, we can find a part of these features integrated in the general adaptation strategy (Gómez, 2016; Soualah 2014; Harchay, 2015), that includes adaptation related to communication.

Table 2. Classification of Context-Aware M learning System

Authors	Adaptation	Context entities							Context modeling	Context acquisition	Sensors	Device
		Learning context	Mobile context									
			LTI	p	Pl	Art	T	PC				
Gomez et al 2016	**Feedback & Support**	√	√		√	√	√	√	Ontology	Ui Sensors	GPS-BLE-QR-RFID	PDA, Smartphone
Gomez et al. 2014	**General Adaptation**	√	√	√	√	√	√	√	Ontology	Ui	/	PDA, Smartphone
Hsu et al. 2016	**Navigation to locations**	√			√		√		DB Rel	UI Sensors	RFID	PDA
Sevkli et al. 2017	**Selection**	√	√		√		√		Ontology	Ui Sensors	GPS	Smartphone
Soualah et al. 2014	**General Adaptation**	√	√		√	√	√	√	Ontology	UI Sensors	Wifi GPS	PDA, Smartphone, Tablette
Marcelo 2016	**Selection**	√			√	√	√	√	/	UI Sensors	Wifi GPS	PDA, Smartphone
Harchay et al 2015	**General Adaptation**	√			√	√	√		Ontology	UI	/	PDA
Bingxue et al 2016	/	√				√			Ontology based, DB (relational)	UI Sensors	/	PDA

LTI: Learner temporal information Art: Artifact T: Time PC: Physical conditions P: People PI: Place

This in-depth analysis can help us to propose our specific learning system with proper structure and functionalities. Synthesizing from the above systems and referring to the relevant work of Gomez we identify four Objectives, which need to be considered when we design a context-aware mobile learning system, including

- O1: Defining a context model for identifying and describing the information that can be used to characterize the situation of a particular entity.
- O2: Implementing context-aware and mobile adaptation processes for both design and delivery approaches of the learning design.
- O3: Designing exemplary context-aware mobile educational scenarios so as to explain and present how possible adaptations can be incorporated.
- O4: Delivering pedagogical-enhanced and structured adaptive and context-aware educational scenarios via mobile devices.

6. CONCLUSION

This paper presented the literature review of context-aware learning systems. This is an active research field that has been produced, since the last decades. We noticed that although, a large body of proposals covering the context- aware learning systems under various different perspectives and some proposals report further enhancements on learning systems, the field still suffer from the major limitation of context-aware learning systems. We believe that this survey will be useful for researchers and practitioners interested in the area of context-aware u- learning system to do research on new dimensions.

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