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CRITICAL FACTORS IN MOBILE LEARNING: A QUASI-SYSTEMATIC REVIEW

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ABSTRACT

The advance of mobile industry and research has expanded e-learning in order to support an efficient and effective educational process. However, the promised benefits are as much attractive as the existing difficulties and barriers. In this paper, we intend to identify and summarize the critical factors in mobile learning through a quasi-systematic review. Preliminary results are grouped on categories defined in previous studies accomplished by the researchers.

KEYWORDS

Mobile learning; e-learning; systematic review; empirical studies.

1. INTRODUCTION

The management of information over massive volumes of distributed multimedia data, and the participative and universal access to knowledge for citizens have contributed to the Web development in 90s, with a special interest in the educational domain (Santos et al., 2012). The goal is to propitiate an environment to make the Information and Communication Technologies (ICTs) closer to the called "international" citizens – out of the traditional physical barriers to the teaching and learning process. On the other hand, the establishment of the "Web Era" underpinned "Mobile Era" in 2000s. In the beginning, mobile devices were focused on telecom domain. However, these devices have been used as processor-based technologies and have become a large part of people's daily lives. Due to the growth and practicality of smartphones, these were the ones chosen for the development of the mobile learning systems (Pettersson et al., 2010).

Mobile learning is a type of e-learning, i.e., the use of technologies and tools to facilitate the teaching and learning process (Girão et al., 2012). The difference is its support by mobile devices as a complement to distance education (Wains and Mahmood, 2008). Thus, the mobile learning research explores issues related to bringing education to mobile devices and vice versa (Pettersson et al., 2010), and also shows a diverse field with a plethora of theories and practices implemented in a variety of projects (Frohberg et al., 2009). For example, *on the technological side*, a challenge consists in supporting devices with variable capabilities, which impacts learning activities themselves to provide a personalized path for every student, *on the application side*. Finally, as discussed by Allan (2010), mobility itself should be investigated, e.g., how to manage and leverage context changes. These challenges are beyond the traditional systems and devices' projects and designs.

In the Brazilian case, for instance, the 2010 census had shown 194 millions citizens and an interesting fact: this number is lower than the number of mobile devices – 202 millions (Teleco, 2011). Based on the governmental efforts as well as the facilities in using mobile Internet, the mobile learning can be the technology to support improvements in education. Our research group has contributing to this global (and national) challenge through the mapping of bandwidth world status and an application of mobile learning in negotiation domain. However, the promised benefits of mobile learning are as much attractive as the existing difficulties and barriers. In this paper, we intend to formally identify and summarize the critical factors in mobile learning through a quasi-systematic review. Preliminary results are grouped on categories defined in previous studies accomplished by the researchers. This initial study will base our initiatives in supporting negotiation learning through mobile and Web platforms. Besides this section, the paper is organized in the following: Section 2 presents the quasi-systematic review and Section 3 concludes the paper.

2. MOBILE LEARNING: A QUASI-SYSTEMATIC REVIEW

This section presents a quasi-systematic review to formally identify and summarize the critical factors in mobile learning through an item-based protocol as following. Using the GQM (Goal/Question/Metric) approach (Basili et al., 1999) to **define the research focus**, the approach goal *is* to analyze mobile learning systems *for the purpose of* classifying *with respect to* identify critical factors (including those related to the act of negotiating) from the Computer Science researchers' *point of view*, *in the context of* each publication. The **research question** (RQ) could be established as: **RQ –** *What are the critical factors in mobile learning?*

2.1 Review Plan

The review steps can be structured through a plan (Biolchini et al., 2007). The steps for executing the quasi-systematic review were pointed out: (i) ***search string***: define the string based on keywords (or synonymous) obtained from PICO (**P**opulation, **I**ntervention, **C**omparison and **O**utcome); (ii) ***source selection***: define the libraries where the primary studies will be searched for; (iii) ***studies selection***: define the process of selecting the relevant studies based on quality criteria; (iv) ***data extraction***: define and extract which data should be collected from the selected studies in order to answer the RQ; and (v) ***result summarization***: analyze the information and group the studies aiming at effectively answer the RQ.

In the step (i), the **population** is the group that will be observed by the intervention; in case, *publications on mobile learning*. The **intervention** consists in what will be observed in the context of the study; in case, *mobile learning systems*. The **comparison** focuses on analyzing some specific parameters in order to show contrasts and other kinds of differences; in case, *critical factors, including those related to the act of negotiating* (this was considered due to the future work). The **outcome** is the metrics used to measure the effect, i.e., the types of results expected in the end of the study; in case, *it is the same of intervention* and the goal is to provide a *classification based on the critical factors found in the included studies*.

Considering the step (ii), the scientific libraries selected for the search were *IEEExplorer*[1], *Scopus*[2], and *ScienceDirect*[3]. The studies language should be English and they must be available at Internet, since the search is done in Web engines. In turn, the step (iii) has established the **studies inclusion and exclusion criteria**: the studies must present mobile learning systems and a discussion of critical factors (including those related to the act of negotiating). The procedure consisted in: running the search string at the selected Web engines; joining the abstracts of the initial set of studies and reading them in order to evaluate according the mentioned criteria; and reading the full text for included studies.

The reasoning related to steps (i) and (ii) generates an initial search string with many synonymous for "mobile", i.e., *mobility* and *mobile device*, as well as for "systems", i.e., *program*, *tool* and *decision making support*; the word *negotiation* was included due to the future interest in using mobile leaning for negotiation. However, the number of results was almost one thousand papers, because these synonymous had contributed to retrieve researches about networking and communication. Thus, the search string was refined and its final structure is the following:

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(negotiation) AND ("mobile learning" OR "mobile ecosystems") AND (system OR software)
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2.2 Review Execution

Since the review plan was finished, the search string was formally executed at the selected Web engines and the results are shown in Table 1. First of all, 234 files were originally retrieved from the Web engines, including 5 repeated papers. After removing these papers, the set has been reduced to 199, which were analyzed by the researchers, considering titles and abstracts. 75 papers were selected from this step to read the full text. Finally, 28 papers were effectively included to the data extraction. So, the step (iv) described in Section 3.1 was executed. The researchers focused on extracting the following five types of data previously included in the review plan:

[1] http://ieeexplore.ieee.org
[2] http://www.scopus.com
[3] http://www.sciencedirect.com/

- Year of publication;
- Vehicles of publication: *journal* or *event* (i.e., proceedings);
- Focus of the paper: *model* (e.g., framework, architecture etc.), *tool* (e.g., prototype, infrastructure etc.) or *case study* (e.g., observational case, interviews etc.);
- Type of negotiation scenario: *business case* (i.e., negotiation in a commercial scenario) or educational case (i.e., negotiation in teaching and learning activities);
- Critical factor for mobile learning (i.e., research contribution).

Table 1. Results from the refinement process

Web engines	Results	Duplicated papers	Analyzed papers	Selected papers	Included papers
1. *ScienceDirect*	49	0	199	75	28
2. *Scopus*	60	5			
3. *IEEExplorer*	125	30			
Total	234	35			

2.3 Data Extraction and Result Summarization

From the 28 papers included after refinement process, the researchers extracted the data based on the scope, as shown in Table 2. Finally, the step (v) could be completed. As the RQ requires, the Table 2 shows the critical factors in mobile learning (last column). First of all, (1) the papers were published in the last ten years, *more than a half of them from 2011 and in journal vehicles*. A reason for this can be the fact that mobile learning research is growing based on the establishment of the "Mobile Era", and many case studies were executed since it consists in a real and large application of recent Computer Science research. Thus, researchers used real scenarios and domains in order to verifying models and tool, and also generating indications and/or evidences in mobile learning empirical research. Moreover, the empirical basis can explain the number of papers related to proposition of models such as ontologies, frameworks, architectures, context-aware structures, user experience techniques etc.

Table 2. List of quasi-systematic review results and extracted data

ID	Reference	Year	Vehicle	Focus	Type of Negotiation	Critical Factor in Mobile Learning
1	Alvarez et al.	2011	Journal	Case Study	Educational Case	Tablets PCs strengthen collective discourse
2	Arroyo et al.	2008	Journal	Model	Educational Case	Context-aware information based on calendar
3	Basit and Matskin	2011	Event	Model/Tool	Educational Case	User Model, User Experience and Places/Spaces
4	Bollen et al.	2004	Event	Model/Tool	Educational Case	Communication based on sending short messages
5	Botick et al.	2011	Journal	Model	Business Case	Collaboration and groups creation
6	Chung	2012	Event	Model/Tool	Business Case	Communication patterns and protocols (reality)
7	Darabant and Todoran	2006	Journal	Tool	Business Case	Data synchronization using wireless technologies
8	Fachrunnisa and Hussain	2013	Journal	Model/Tool	Business Case	Trust in industrial digital ecosystems
9	Fallahkhair et al.	2005	Event	Tool	Educational Case	Television and mobile phone assisted language
10	Feijó et al.	2009	Journal	Model	Business Case	Different origins/cultures and diversity of content
11	Gerosa et al.	2010	Journal	Case Study	Educational Case	Mobile notifications for better forums
12	Infante et al.	2009	Journal	Model/Tool	Educational Case	Single Display Groupware with Multiple Mice
13	Kallenback et al.	2010	Event	Case Study	Educational Case	Learners' stress (heart rate and skin conductivity)
14	Khan and Matskin	2011	Event	Model	Educational Case	Spaces/Places in multi-agent systems
15	Lan et al.	2011	Journal	Model/Tool	Business Case	Imprecision and uncertainty (fuzzy systems)
16	Lan and Sie	2010	Journal	Case Study	Educational Case	Communication comparison (SMS, e-mail, RSS)
17	Lan et al.	2012	Journal	Case Study	Educational Case	Online asynchronous discussion (feedback)
18	Li et al.	2011	Event	Model	Educational Case	Augmented reality
19	Liu et al.	2007	Event	Tool	Educational Case	Shared display groupware (tete-a-tete-oriented)
20	Nguyen and Pham	2012	Event	Model/Tool	Business Case	Context-aware mobile learning architecture
21	Pimmer et al.	2012	Journal	Case Study	Business Case	Integration to social network sites
22	Su et al.	2011	Journal	Tool	Business Case	Data mining (clustering/decision tree approach)
23	Trifonova and Ronchetti	2004	Event	Model	Educational Case	Context discovery and mobile content adaptation
24	Tsai et al.	2011	Journal	Case Study	Business Case	Evolve business environment to be mobile-based
25	Tsai et al.	2012	Journal	Case Study	Business Case	Realistic and close-to-real-life information
26	Wang et al.	2002	Event	Tool	Business Case	e-marketplace based on agents and mobile agents
27	Zhao et al.	2010	Event	Model	Educational Case	Learners get instant help from other participants
28	Zurita et al.	2007	Journal	Model/Tool	Educational Case	Domain context and physical proximity

Second of all, (2) *more than a half of the papers* has focused on mobile learning-based negotiation considers the educational case – the actors are students and teachers, the platform is a web and/or mobile-based infrastructure, and the artifacts are the learning activities, contents, discussions and notifications. This indicates that negotiation leaning should be more explored in a business perspective, in specialized platforms and infrastructures. Finally, (3) the main critical factors of mobile learning can be summarized in ten categories, as shown in Table 3. These categories were elaborated by the researchers considering the studies (Rodrigues et al., 2011) and (Girão et al., 2012). The main five categories are: *human and business aspects*, *medias integration*, *communication*, *context-aware* and *collaboration*. However, it is important to observe that the other categories correspond to new initiatives to explore mobile learning in negotiation, considering the new practical trends in this decade (e.g., augmented reality and social networks).

Table 3. Categories of critical factors mobile learning

Categories	List of references (ID)
Place and Space	3, 14
Groups creation	5
Medias integration	7, 9, 12, 19
Data mining	15, 22
Augmented Reality	18
Social Networks	21
Human and business aspects	8, 10, 13, 24, 25, 26
Collaboration	1, 17, 27
Communication	4, 6, 11, 16
Context-aware	2, 20, 23, 28

3. CONCLUSION

Since Computer Science has been established as the "third pillar" in a transition from Web Era to Mobile Era, many approaches for mobile learning are emerging in the last years. So, this paper formally identifies and summarizes the critical factors of mobile learning as the main contribution. A quasi-systematic review plan were established and executed in order to preliminary discuss data extraction and results summarization. The results were grouped based on categories defined in previous studies accomplished by the researchers. As a future interest, we observed that mobile learning-based negotiation is being a topic in the last ten years, especially from 2009. Thus, a deeper analysis of the results should be done as well as a complete systematic review focused on Web- and Mobile-based environments aiming at comparing the results with this initial research in mobile. A list of tools will be generated to compare them considering the mentioned categories in order to establish an environment to supporting negotiation learning based on Web and mobile platforms.

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