

A Learning Design and Analytics Perspective of Mobile and Ubiquitous Learning

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Abstract. Mobile and ubiquitous learning models are finding an increasing adoption in technology-enhanced learning (TEL). Despite the potential benefits, they also entail additional complexity in designing, monitoring and evaluating learning activities. Learning design (LD) and learning analytics (LA) communities have started to address these issues. This paper presents an overview of how these communities understand mobile and ubiquitous learning, and how they have contributed to them. The search included 7 main academic TEL databases, resulting in 1722 papers out of which 54 papers were included in the final in-depth analysis. Results point out trends and synergies between both communities. Results emphasize the absence of common definitions for mobile and ubiquitous learning, research trends and unexploited synergies between the communities of LD and LA, as well as areas where further investigation is needed.

Keywords: Mobile learning · Ubiquitous learning · Learning Design · Learning Analytics · Systematic literature review

1 Introduction

Mobile learning (m-learning) and ubiquitous learning (u-learning) have become recognized terms in the field of TEL, often used interchangeably [3]. Although there is no consensus about their meanings, it is accepted that they promote among others: accessibility, interactivity, self-regulated and situational learning, continuity and connectivity among contexts [12, 3]. Further, both these terms tend to be characterized by hybrid learning environments where learning happens between physical and digital spaces, and through a combination of physical and digital tools. Despite the potential benefits, m-learning/u-learning pose multiple challenges [2]. For example, in these settings learning usually happens across multiple spaces, where designing pedagogical scenarios would involve the use of different authoring tools, specific for each space (e.g. Smartzoos, for designing learning activities in geo-located physical spaces [10]). Monitoring and evaluating in these contexts requires gathering data from different spaces in order to achieve a global view of the learning process [8].

In the last 15 years, several contributions in the areas of LD and LA have been proposed to address these issues. Nevertheless, several design challenges and implications need to be faced [13], and analyzing students' learning behaviour and patterns still remains an open issue in m-learning [4]. There has also been a growing number of research on the synergy between LD and LA [2, 7]. However, Mangaroska and Giannakos [7], in systematic review on LA for LD identified only one work related to m-learning/u-learning.

In this paper, we carry out a systematic review to better understand the role that the LD and LA communities may play in m-learning and u-learning, and how they could enrich each other. Research questions addressed are: (RQ1) what are the definitions and aspects of m-learning/u-learning which have been considered by the LD and LA communities?; (RQ2) which learning settings, learning spaces, and target users characterized the learning contexts where LD/LA supported m-learning/u-learning?; (RQ3) what kind of LD and LA contributions are found in m-learning/u-learning publications?

2 Methodology

To conduct the review, we followed Kitchenham and Charters' guidelines [5]. We selected seven main databases in TEL (ACM Digital Library, AISEL, IEEE XPLORE, SpringerLink, ScienceDirect, Scopus, and Wiley) and Google Scholar to detect potentially relevant grey literature. To build the query, we split the question into the learning settings and the research field where the proposal was framed, resulting in: ("learning design" OR "learning analytics") AND ("mobile learning" OR "ubiquitous learning"). The literature search was conducted on April 4, 2019, obtaining 1622 papers. Additionally, the top 100 results from Google Scholar were added. To ensure that the keywords played a significant role, we narrowed the query to title, abstract and keywords, resulting in 209 papers. Each paper was reviewed by at least two researchers to discard those not satisfying the inclusion criteria: use of the keywords as a core part of the paper, written in English, and at least 4-pages long. Doubtful cases were discussed among all researchers. Finally, the resulting 54 papers¹ were analyzed in detail.

3 Results

Attending to the query, 28 papers (51.9%) referred to LD, 23 (42.6%) to LA, and 3 (5.6%) to both LD and LA. Thirty (55.5%) papers used the term m-learning, 15 (27.8%) used u-learning, while 9 (16.7%) used both terms.

Definitions of m-learning/u-learning. To answer RQ1, we explored the definitions of m-learning/u-learning, as used by the communities of LD and LA. From m-learning, 19 papers took the definition for granted, 14 provided their own definition, while 13 referred to other authors (mentioning more than 10 different publications). Despite the myriad of definitions, core aspects were mentioned

¹ Reviewed papers: <https://gitlab.com/gertipishtari/list-of-papers>

across different papers, especially mobile technologies (15), learning anytime, anywhere (13), context-aware learning (5), and user mobility (7). Similarly, in u-learning, 15 took the definition for granted, 6 referred to other authors, and 6 provided their own definition. In this case, the main aspects highlighted by the authors were learning anytime, anywhere (7), context-aware learning (6), and ubiquitous computing technologies (4). The communities of LD and LA share a common understanding of the terms, as they did not show significant differences between them when referring to m-learning and u-learning. It should also be emphasized that we did not identify any specific author, or paper offering a definition that was largely cited. LD and LA communities also seem to relate similar aspects to both m-learning and u-learning, such as learning anytime, anywhere, or context-aware learning.

Learning context. To better understand RQ2, we clustered the papers according to the learning settings, educational level, spaces, and target users (users for whom the LD/LA functionalities were described in a paper).

- *Learning settings.* In total 26 papers (48.2%) targeted formal learning, 8 (14.8%) informal learning (including non-formal learning), 2 (3.7%) both of them, while 18 (33.3%) did not specify the type of learning. In formal learning, 24 papers addressed university settings, while 8 K-12 education. Regarding informal learning, 4 papers were for university students, 3 papers were explicitly open to all users, 1 was for children, and 2 did not specify. While both LD and LA have mainly focused on formal learning (13 and 16 papers, respectively), most of the cases with unspecified type of learning belonged to LD papers (14).

- *Learning spaces.* In terms of spaces, 11 papers discussed learning activities indoor (mainly in the classroom), 7 learning activities outdoor (e.g., city or parks), while in 22 papers learning activities happened on both settings. The most common combination was across physical and digital spaces with 39 papers, followed by 4 in several digital spaces, 2 in a single digital space, while 8 papers did not specify it. In general, LD has focused on indoor activities (5), as well as in both settings (16), while LA had a balanced distribution between outdoor (7), indoor (6), and on both (8). For example Muñoz-Cristóbal et al. [9] describe the system GLUEPS-AR, which supports teachers in deploying and enacting LDs across physical and digital spaces, indoor and outdoor, while Lkhagvasuren et al. [6] propose a Dashboard (L2D), to track, analyze and visualize data about language learning activities that happen in a digital space.

- *Target users.* While learners, teachers, instructional designers, researchers and developers were mentioned, it was teachers (37, or 68.5%) and learners (22 papers, or 40.7%) who attracted more attention. When we look at m-learning and u-learning separately, we notice that m-learning has focused also on instructional designers (17 from 30 for m-learning vs 5 from 15 for u-learning). LD papers focused on teachers (25) and instructional designers (15), while LA papers focused equally on learners (15), followed by teachers (15). There are no differences on the focus of LD and LA communities when we consider separately m-learning and u-learning contributions.

Types of contributions. Similar amount of contributions were found from each community. LD contributions have been more theoretical than practical (25 versus 11), while LA contributions have a theory-practice balance (19 versus 17). All 3 papers related to LD and LA offered practical contributions. Both m-learning (33 versus 15) and u-learning (19 versus 13) offer more theoretical contributions. At the theoretical level, LD contributions have been guidelines (17), models (6) and frameworks (6). LA theoretical contributions have been data analysis (8), models (8), and guidelines/good practices (8). Practical contributions such as ILDE [1], or QuestInSitu [11] in LD were expected to be used mainly before (10) and during (11) learning activities; while in LA, contributions such as SCROLL [6] were used during (16) and after (10) learning activities.

LD functionalities were mainly designed to support the design of learning activities (29), while LA functionalities have been mainly directed to help teachers orchestrate the learning process through providing personalized feedback (17), and support the reflection about the learning activities (10). LA for LD papers also emphasized aspects such as raising awareness about LD practices and support the evidence-based decision making.

4 Implications and future work

The review reveals that, despite the lack of a shared definition, LD and LA communities emphasize similar aspects of m-learning and u-learning. Regarding the context of application, the most significant finding is related to the target users. Unexpectedly, while traditionally LA communities have targeted mainly teachers, as seen from the results the LA contributions under review have largely focused also on learners. This fact can be explained by the self-regulate nature of m-learning/u-learning that emphasizes the student role. This result might imply that there might be space for some more effort from the LA community in order to support further self-regulated learners in m-learning/u-learning. Similarly to what other reviews have shown in the areas of LD and LA, most of the works under review focused on university settings. Therefore, there is still room for exploring the benefits in other contexts such as K-12 and non-formal settings. Despite the fact that both communities can complement each other in m-learning/u-learning, we notice a low number of papers that include aspects from both LD and LA (3). Traditionally LD has supported participants before the learning activity, and LA during and after. Nevertheless, as mentioned by the LA literature [7, 2], these two communities can join efforts and close the loop in m-learning/u-learning: where LD can be used to guide and contextualize the analysis, making it more meaningful for the different stakeholders. Also, LA can contribute to inform design decisions as well as to evaluate the LDs.

A limitation of the current review is related to the keywords chosen for the query. Related terminology that was not included, such as seamless learning for the learning context, scripting for LD, or educational data mining for LA, could have left out complementary contributions to the list of works under review. Nev-

ertheless, before choosing the query that we use in this review, we experimented with different combinations and compared the respective obtained results.

Future work will extend the review by further exploring the interplay of the LD and LA in m-learning and u-learning. We will extract more detailed aspects about the learning context, the core aspects to be designed or monitor in m-learning/u-learning, the maturity of the contributions, the main challenges to be addressed by the LD and LA communities, and the potential synergies that both may bring to the contexts of mobile and ubiquitous learning.

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