The Impact of New Technologies on Learning: A Literature review on Mobile Collaborative Learning

Research-in-Progress

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Abstract

Mobile Collaborative Learning (MCL) has recently caught the attention of the research community because of its potential impact on improving learners' effectiveness and performance. Nevertheless, to be really effective, the potential of MCL-based solutions is still largely unexplored, as well as further research is needed to develop improved learning environments. This literature review aims to discuss the possible impact of MCL, looking at a number of typical parameters, such as user satisfaction, perceived ease-of-use, perceived usefulness, impact on the affective and cognitive domain, and perceived enjoyment. The literature review has pointed out that, by adopting the MCL approach, learners improve their motivation, as well as their cognitive skills. It points out a positive impact also at an affective level. Additionally, we found that MCL currently targets education at any level, including university and school level. Last but not least, it seems to positively affect also learning outcomes, namely learners' performance. On the negative side, the study found a lack of research attention on possible difficulties, constraints, and barriers. Finally, learning environments are expected to become more and more sophisticated in the next future (e.g. by using augmented reality), and mobile technology is expected to play an even more relevant role.

Keywords: Collaborative Learning, E-Learning, Cognitive Learning, Educational Technology

Introduction

Technology is quickly evolving, and its advances are leading to a progressive enhancement of several aspects of life (Røpke 2001). Also, the extensive use of technology as part of everyday life provides, among others, easy access to information all over the World, as well as it changed radically the way in which people interact with each other (Bonk 2009). Education is an essential part of our life as it plays a significant role in building a mindful and responsible society by increasing social standing and awareness among people, as well as people's values (Bhardwaj 2016). Technology evolution has also affected education. Firstly, technology has made it simple for learners to access great amounts of information through the Web. It led to the e-learning concept (Martins and Baptista Nunes 2016). E-learning quickly emerged and continued to evolve over the years by defining new models for education. It empowered learning approaches different from the traditional ones (e.g. Cognitive Learning (Martins and Baptista Nunes 2016)). More recently, e-learning embraced mobile technology to define the mobile

learning approach, commonly referred to as m-learning (Gan and Balakrishnan 2017). M-learning aims to provide a more interactive learning environment assuming the active use of mobile devices (Gan and Balakrishnan 2017). In such a way, mobile technology will be a new layer added to education and teaching methods (Ally J. 2014). M-learning has further contributed to facilitating distance learning and training without adherence to the political and geographical boundaries of the learners (Crane et al. 2011). It assures higher flexibility for learners. Mobile learning relies on the always-connected principle (Ally et al. 2007). The benefits of adopting mobile technologies in learning have been discussed in several contributions (e.g. (Grønli et al. 2014; So 2016)). It is commonly assumed that m-learning can provide key features to establish and make effective collaboration within the learning environment (Mobile Collaborative Learning - MCL(Pasi Silander Jorma Tarhio 2004)). Additionally, according to the last social and technological trends, the combined use of mobile technology and online social networks intrinsically facilitates MCL environments in which mobile learners can easily collaborate and share knowledge and experiences, as well as they can effectively interact with each other (Kim, M. Lee, et al. 2014; Navaridas et al. 2014; Pasi Silander Jorma Tarhio 2004). In this paper, we conduct a literature review aimed to discuss the possible impact of MCL, looking at a number of typical parameters, such as user satisfaction (Information et al. 2014), perceived ease-of-use (Davis 1989), perceived usefulness (Davis 1989), impact on affective and cognitive domain (Wikipedia 2019), and perceived enjoyment (Moon and Kim 2001).

Methodology and Approach

This study adopts the methodology suggested in (Budgen and Brereton 2006; Kitchenham, B. and Charters 2007; Kitchenham et al. 2009), which have been successfully applied to literature reviews in the area of Software Engineering. It relies on the association of the different contributions with given objectives. The resulting conceptual framework has considered an initial list of 212 articles. Those articles have been found in most common scientific databases as in Figure 1. The search was conducted by combining the keyword "Mobile Collaborative Learning" with "affective", "emotion", "platform" and "cognitive". Those contributions have been selected to include works that deal with some aspect of e-learning. Such a framework prioritizes six different parameters: perceived ease-of-use, perceived usefulness, impact on affective domain, impact on cognitive domain, perceived enjoyment, and satisfaction. 22 papers out of the initial 212 have been selected based on the following criteria:

- explicit focus on Mobile Collaborative Learning not just m-learning or e-learning approaches;
- focus on novel learning approaches based on the adoption of emerging or cutting-edge technology;
- as mobile technology is relatively recent and constantly evolving (ITU Union 2019), we included in our research only recent papers (published after 2010) to address last generation solutions;
- we have considered only papers that provide a clear contribution according to the target parameters previously mentioned and that specify the target group for the study.

Looking at this restricted number of contributions, we have identified research gaps and possible directions for further research and development. The time distribution for initial and selected contributions is shown in Figure 2. The popularity of e-learning constantly increases along the time. A very significant part of papers on e-learning (186 out of 212) deals with m-learning approach.

Resources and Databases	**Founds**
Scopus (Elsevier)	20
Proquest (proquest science and technology)	10
IEEE xplore	13
EBSCO (computer and applied science complete)	2
Springer link	52
Ovid	3
Taylor and francis online	4
Science direct	95
Google scholar	8
ACM (digital library)	12
Total of downloaded	219
Duplicated	7
Total of papers	**212**
Chosen for the literature review	**22**

Figure 1. Papers retrieved from the different databases

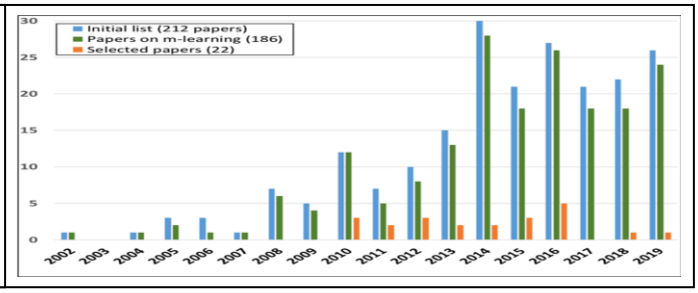

Figure 2. Time distribution of reviewed contributions

Reviewing Mobile Collaborative Learning

Recent statistics show an increasing adoption of mobile technology since 2000, when it was estimated less than 1 billion of mobile devices worldwide against more than 8 billion reached at the beginning of 2019 (ITU Union 2019). This clear trend is affecting, and it is expected to further affect the educational sector in which mobile technology is expected to be more and more relevant. The primary goal of MCL is to allow learners to increase their learning performance (Martin and Ertzberger 2013) and experience. MCL allows learners to collaborate regardless of their actual geographical location. In such a way, learning is customizable and flexible and it may be functional to specific and changing needs. MCL can be adopted in practice in many different ways depending on the context to achieve different goals. A brief overview of applications in practice of MCL is proposed in Table 1.

Table 1. Mobile Collaborative Learning adoption in practice

Reference	Adoption of Mobile Collaboration Learning
(Liu and Chu 2010)	Using ubiquitous tools without using a textbook in the classroom.
(Chu et al. 2010)	Using the ubiquitous environment to access digital resources while learning in real-world scenarios.
(Guerrero et al. 2010)	Using software tools for individual tasks or face to face group tasks in the classroom.
(Cavus 2011)	Using Learning Management System, e-mail, videoconference, and MMS through mobile devices.
(Holotescu and Grosseck 2011)	Using mobile multimedia and SMS messages in the classroom.
(Ryu and Parsons 2012)	Combined use of mobile and non-mobile learning. Individual learning supported by MCL.
(Mitroiu 2012)	Facebook app to share multimedia content
(Schaal et al. 2012)	Outdoor mobile technology, e.g. Google Maps or other geo-located services.
(Furió et al. 2013)	Using augmented reality video game vs. traditional game.
(Fresno 2013)	Using mobile technology in and out classroom.
(Kim, M. Y. Lee, et al. 2014)	Mobile Instant Messaging group vs. Personal Computer-based Instant Messaging group vs. Bulletin Board System group.
(Hyman et al. 2014)	Using mobile devices in their course, such as an electronic reader, a tablet.
(Garcia-Cabot et al. 2015)	E-learning platform vs. m-learning.
(Reychav and Wu 2015)	Text vs. video
(Liaw and Huang 2015)	Interaction among teachers and students.
(Sabah 2016)	Incorporate mobile technology into their learning environment.
(Harley et al. 2016)	Augmented reality for a directed historical tour.
(Reychav et al. 2016)	Using social media into mobile learning.
(Balakrishnan and Gan 2016)	Combined use of social networking and educational tools.
(Reychav and Wu 2016)	Non-interactive vs. interactive mobile learning application at an individual and group level.
(Fabian et al. 2018)	Mathematic problems.
(Rejón-Guardia et al. 2019)	Personal Learning Environment.

Technological Perspective

Looking at MCL from a technological perspective (Figure 3), we found that MCL solutions are often part of Learning Management Systems (LMS), as well as they often offer implementation as mobile apps. As expected, there is an extensive use of multimedia content and some novel future based on advanced technology (Augmented Reality). With some surprise, the direct use of Social Networks is relatively low.

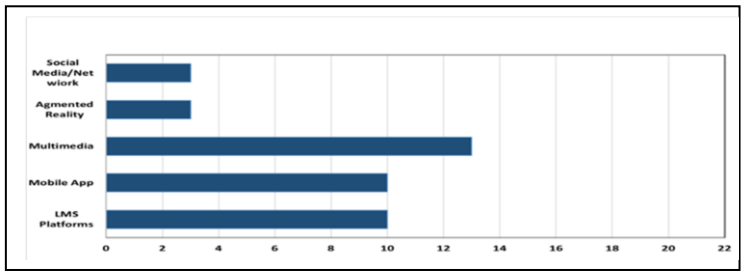

Figure 3. Technological perspective

Target Groups

In this context, a target group is defined as a group of learners who use some MCL-based solution along the learning process. This literature review found that MCL applications target both university-level (59%) and school (41%) students. More concretely, 18% of solutions are for postgraduate, 36% for undergraduate, 5% for college, 27% for primary school, and 14% for secondary school.

Assessment Based on Selected Criteria: Quality of Experience and Emotional Perspective

We have investigated the use of our assessment criteria in the various contributions. Perceived usefulness (PU) and perceived ease-of-use (PEOU) are defined according to the Technology Acceptance Model (TAM)(Davis 1989). The former concept is associated with user perception in terms of value, while the latter is more related to usability. The third criterion, User satisfaction (US), reflects the quality of experience. The affective domain (AF) addresses feelings and, more in general, the emotional area. The impact on the cognitive domain (CO) considers mental skills, and it is indeed related to learning performance and motivation. Finally, perceived enjoyment (PE) aims at measuring the enjoyment of learning.

The use of the different selected criteria in the various contributions is reported in Table 2. Most contributions adopt at least one of the considered criteria. Only three selected papers (Furió et al. 2013; Liaw and Huang 2015; Rejón-Guardia et al. 2019) adopt all criteria, while other works adopt some of them. Overall, looking at the studies that adopted the first three parameters (US, PEOU, and PU), learners are satisfied in terms of outcomes and learning environments. Moreover, ease-of-use seems to have a direct positive influence on learning enjoyment, as it results in a less stressful user experience. Also, when learners perceive the usefulness of an additional learning value, the benefit is perceived at an affective level. It leads to increased motivation and cognitive performance.

We want to remark that users reported in general a very good quality of experience. However, such an experience becomes even better when ease-of-use and usefulness are recognized together (Balakrishnan and Gan 2016; Cavus 2011; Furió et al. 2013; Garcia-Cabot et al. 2015; Hyman et al. 2014; Liaw and Huang 2015; Rejón-Guardia et al. 2019). Learners who use MCL in their learning show some increase in their cognitive performance (Balakrishnan and Gan 2016; Garcia-Cabot et al. 2015; Reychav and Wu 2015, 2016). MCL is personalized as a training tool (Garcia-Cabot et al. 2015). Text channel is effective in collaboration (Reychav and Wu 2015), as well as social media provides benefits and flexibility (Balakrishnan and Gan 2016). Finally, real-time interactions among learners are the key feature in (Reychav and Wu 2016). Last but not least, the affective state (especially enjoyment) drives motivation and has a clear impact on cognitive learning performance and may strongly influence future intentions (Balakrishnan and Gan 2016; Cavus 2011; Furió et al. 2013; Garcia-Cabot et al. 2015; Guerrero et al. 2010; Harley et al. 2016; Liaw and Huang 2015; Liu and Chu 2010; Rejón-Guardia et al. 2019; Reychav and Wu 2015).

Table 2. Mobile Collaborative Learning Assessment Based on Six Different Criteria

Reference	Assessment (✓= adopted ×= not adopted)					
	US	PEOU	PU	AF	CO	PE
(Liu and Chu 2010)	✓	×	×	✓	✓	✓
(Chu et al. 2010)	×	×	×	×	✓	×
(Guerrero et al. 2010)	×	✓	×	✓	✓	✓
(Cavus 2011)	×	✓	✓	✓	✓	✓
(Holotescu and Grosseck 2011)	×	×	×	✓	✓	×
(Ryu and Parsons 2012)	×	×	×	×	✓	×
(Mitroiu 2012)	×	✓	×	×	✓	×
(Schaal et al. 2012)	✓	×	✓	×	✓	×
(Furió et al. 2013)	✓	✓	✓	✓	✓	✓
(Fresno 2013)	×	×	✓	✓	✓	×
(Kim, M. Y. Lee, et al. 2014)	✓	×	×	✓	✓	×
(Hyman et al. 2014)	×	✓	✓	✓	×	✓
(Garcia-Cabot et al. 2015)	×	✓	✓	✓	✓	✓
(Reychav and Wu 2015)	✓	×	×	✓	✓	✓
(Liaw and Huang 2015)	✓	✓	✓	✓	✓	✓
(Sabah 2016)	×	✓	✓	×	×	×
(Harley et al. 2016)	×	✓	×	✓	✓	✓
(Reychav et al. 2016)	×	✓	×	×	✓	✓
(Balakrishnan and Gan 2016)	×	✓	✓	✓	✓	✓
(Reychav and Wu 2016)	✓	✓	×	×	✓	×
(Fabian et al. 2018)	✓	✓	✓	×	×	✓
(Rejón-Guardia et al. 2019)	✓	✓	✓	✓	✓	✓

Open Issues

From this literature review, MCL can be considered as a promising approach for improving learners' performance and experience. However, we believe that, regardless of the unquestionable improved technologic environment, the educational context plays a key role. We expect MCL to be applied to support novel and richer learning approaches and experiences. There are still different aspects of the learning process that could be improved by an effective application of MCL, such as free-riding, increased interaction, and engagement, as well as improved communication among learners (Järvenoja et al. 2019; El Massah 2018; Saunders and Corning 2020). We believe that MCL can play an important role in the context of target groups different from the classic ones. For instance, in the context of lifelong learning, which a kind of self-education (Galynker and Still 1982). It also applies to professional training involving industry and professionals. The work proposed in (Sabah 2016) is the only study that explicitly focuses on possible difficulties and barriers that may affect the use of MCL in practice. Most limitations seem to be related to technological factors, such as the screen size, power constraint, and network connection. This also was reported in (Chen et al. 2009; Theodorou et al. 2018). We believe those factors are not determinant and they will probably become even less relevant in the next future. We believe that the application of new technology (e.g. augmented reality) will further improve the learning context, as well as a more effective adoption of mobility features will contribute in a

determinant way to define pervasive and effective collaboration. In terms of collaboration, we believe that current models could evolve to make the involvement of instructors more active and effective in different learning situations.

Conclusion

This study presents a concise literature review on MCL looking at learning performance and experience in the context of different target groups. Existing studies show that learners have the ability to adopt new technologies in order to engage, interact, and collaborate in an educational context. This is a direct consequence of the massive presence of technology in most aspects of everyday life. It makes the application of such technology easy and direct. Furthermore, COVID-19 pandemic has quickly re-defined the whole teaching scenario whose effectiveness relies in great part on e-learning approaches. However, part of the potential of MCL is still unexplored. This study has also pointed out the importance of personal factors and perceptions. Indeed, the affective domain seems to be strongly related to the cognitive domain and a clear impact on the learning experience. Future work will investigate possible evolutions of the current MCL concept and its applications. We will also be considering additional factors (e.g. personality), as well as more specific approaches in the context of the different disciplines.

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