Collaborative M-Learning Practice Using Educ-Mobile

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Abstract— **A collaborative m-learning experience conducted at higher education in the Northwest of Argentina is described in this article. It was implemented in a postgraduate course using Educ-Mobile, an interactive mobile game. The educational practice was designed using the framework for the Analysis, Design and Assessment of m-learning Experiences (MADE-mlearn). This framework allows the analysis and assessment of existing m-learning experiences and the design of new ones. The results of this experience, considering both learning outcomes and students' satisfaction using the application, are presented. To expand the scope of Educ-Mobile to other specific domains and to elementary and high schools is one of the most important objectives of the authors in the future.**

Keywords - mobile-learning; collaborative technologies; MADE mlearn; Educ-Mobile application.

I. INTRODUCTION

Collaborative learning can be considered an effective strategy to promote student achievement, higher order thinking, argumentation and explanation skills, autonomy, interdependence, retention, problem-solving, self-regulation, and use of metacognitive strategies [1, 2].

Computer supported collaborative learning (CSCL) introduces technology into collaborative learning tasks. It has learning benefits like motivation, elaboration, dialogue and debate, higher-order thinking, self-regulation, metacognitive processes, and divergent thinking [1, 3].

On the other hand, mobile devices have advantages in terms of portability and ubiquity. They are part of people´s everyday life. Based on them, a new way of learning emerged a decade ago: mobile-learning or m-learning. Mobile technology is often presented as a means of stretching the affordances of human communication and collaboration and has repeatedly been claimed to provide greater opportunities to promote collaborative learning [4, 5]. In section II.C some examples are presented.

Woodill [6] proposes three modes of m-learning, taking into account the interaction between learning actors: the mobile device is used only to access information (first mode); in addition, the user can provide information (second mode), and finally, the interaction occurs in various ways creating collaborative learning communities (third mode). The third mode m-learning practices pose a new way to build collective knowledge and to develop student's collaboration skills; these practices are the most difficult to implement but the most desired. Third mode m-learning practices could be identified as collaborative mobile learning.

Effective collaboration is rarely a spontaneous phenomenon but rather the result of orchestration and scaffolding of productive interactions [3]. The challenge for mobile learning research is thus to structure support for collaboration in contexts that are likely to be more dynamic. The authors are directing research which contributes to such objectives. They have developed a framework called MADE-mlearn [7] that allows the design of m-learning experiences for higher education taking into account such aspects as expected learning results, type of interaction, learning context, underlying learning theories and available mobile technologies.

In this paper, a collaborative m-learning experience for higher education is presented. It was designed using the MADE-mlearn. The framework allowed defining the purposes, the deployment context, and the resources of the experience. The main technological resource involved was Educ-Mobile, a collaborative interactive mobile game for Technology Teaching. This software was developed at the National University of Santiago del Estero (UNSE), Argentina. The m-learning experience was also held at this university in 2013.

The experience allowed obtaining preliminary conclusions related to the impact of using collaborative m-learning in postgraduate education. The use of the application in other courses with different contents and in different contexts will allow obtaining sounder conclusions in the future.

Theoretical foundations of MADE-mlearn and Educ-Mobile application are provided in the following paragraphs. Then, the design, implementation and evaluation processes of the learning experience are described.

II. THEORETICAL FOUNDATIONS

A. M-learning

M-learning is based on the ability of people to use mobile network technology to access relevant information or to store new information, regardless its physical location [6]. It is not about delivering content to mobile devices but about the processes of being able to operate successfully in new contexts. It is also about understanding and knowing how to use everyday life-worlds as a learning space [4]. Therefore, technology is not the main issue in mobile learning.

There are many contributions on m-learning, considering only a purely technological perspective [8, 9, 10]. However, it is important to study it from a socio-cultural ecology approach [4]. This is based on the need to explore m-learning from different areas: educational, social, cultural, media, technological and semiotic. The world today is characterized by fluidity, provisionality and instability. Thus, there are different factors that affect learning: socio-economic status, gender, age, generation, ethnicity, region, profession, among others. These define the life-worlds of the learners. This approach states that m-learning is governed by a triangular relationship between: socio-cultural structures, cultural practices and agency. The socio-cultural and technological structures are governing their existence in the world. Cultural practices are routines that people use in their daily life. Agency is the ability of the user to act in the world. The interrelationship between these three elements is seen as an ecology that manifests itself in the form of emerging cultural transformations.

Considering the type of interaction, m-learning can be carried out through three different modes [6]:

Mode 1: Information Retrieval. They provide one-way communication, access to information. Mobile devices can act as clients to retrieve information from the server, where the server is a hosted massive server in the cloud or a simple mark encoded in an object. This implies that the information is not necessarily stored in the learner device but is updated and used just in time. This is always a transaction in only one direction: the information is requested and retrieved by the user.

Mode 2: Data collection and analysis. Provide two-way communication, access to information and answers or sending information to peers or teachers. Each user is a network node that can be used to drive a kind of collective intelligence.

Mode 3: Communication, interaction and collaboration networks. Provide communication in communities. Learning is performed using interactive social applications that run on mobile devices. It is at this level that m-learning shines as it allows social learning that other means do not provide, primarily based on a non-formal group learning where the individual learns 80% of the knowledge they have.

On the other hand, Quinn [11] argues that the benefits of mobile computing can be summarized in four capacities: content, capture, calculation and communication. An m-learning experience tries to transform the content in learner knowledge. The content is processed and stored in digital files. These files could be documents, audio, video, may be on the mobile device, accessible via the web, or downloaded.

Educational materials and resources are one of the components of the core of educational processes. They are the bridge to address different elements of a didactical project: introduction, conceptual presentations, examples, synthesis [11], as well as practice. It is therefore very important to study and define what type of file it is convenient to use to deal with the contents while taking into account learning objectives. From a technical viewpoint, the size and capacity of the mobile device should be considered. The diagrams and videos are suitable for mobile devices. Watching a video is something that can be done comfortably in a mobile phone, and the sound is very convenient as well. This is not the case with large text documents.

All these aspects presented above where considered to build MADE-mlearn framework.

B. Computed-supported collaborative learning

CSCL studies how people can learn together with the help of computers [12]. It considers all levels of formal education from kindergarten to univerity, as well as informal education.

It is useful to distinguish collaborative learning from cooperative learning. Dillenbourg [13] defined the distinction roughly as follows:

- In collaboration partners work together; in cooperation they split the work and then assemble their partial results into the final output.
- Learning in cooperative groups is viewed as something that takes place individually. Learning occurs socially as the collaborative construction of knowledge; the activities that they engage in are not individual-learning activities, but group interactions like negotiation and sharing.

Collaboration is primarily conceptualized as a process of shared meaning construction [12]. Meaning making is not assumed to be an expression of mental representations of the individual participants, but an interactional achievement. Meaning making can be analysed as taking place across sequences of utterances or messages from multiple participants.

Collaboration among peers or others (domain experts, professors, etc.) is an important contribution to students' development [14]. They can provide explanations to issues by generating multiple solutions to problems and including many different kinds of skills in problem solving. However, successful collaboration is not easy to achieve.

From the Piagetian theory, collaboration is important to conceptual growth because of the cognitive conflict that may be engendered by group discussions and arguments. The opportunity for differing opinions in collaborative groups may provoke conceptual change. From the Vygotskian theory, collaboration is important because of both individual and group learning [14]. Individuals may benefit because their learning could be scaffolded by a more knowledgeable or experienced peer. The group may also come to share understanding and involve individuals at different levels of participation.

From a sociocultural approach, collaboration is seen as a community of learners [14].

In CSCL it is important to understand the objective that underpins each educational project in order to design a successful experience.

C. Mobile and collaborative learning experiencies

Worldwide there are quite a number of m-learning projects applied to different educational levels [6, 11, 15, 16]. However, there are a few corresponding to the third mode where collaboration is effectively accomplished. Moreover, not many

published experiences are in higher education [17]. The mobile learning project database, MoLeaP, is a public and free-of-charge online database for teachers, researchers and other (education) professionals interested in learning and teaching with mobile media [18]. This database only displays two projects at higher education: Mobile VLE and Mobile Connections. Both projects belong to the Open University and spread and share information but do not foster the use of collaborative skills, so they are not considered collaborative m-learning projects.

Some collaborative m-learning experiences widely spread in the literature are presented below.

In [19], authors put forth an experience in the use of mobile technologies in higher education based on collaborative learning: a Mobile Computer Supported Collaborative Learning (MCSCL) system to support high-school teachers with wirelessly networked Handheld Computers. The results of the experience show that this system promoted students' collaboration and constructivism (it was tested during a five-week experience in a high-school Physics class). Due to the fact that the experience was in a face-to-face context, it was deprived of the advantage of mobility which allows learning in more valuable contexts outside the class.

In [1], Nouri presents an empirical study aimed at examining the role played by mobile devices, teachers and task structures as a means for collaborative learning in geometry. The study focused on the analysis of the nature of collaboration that unfolded when students measured areas in the field. Although, it is an m-learning collaborative experience outside the classroom with valuable results related to issues that can impair collaboration, it is not concerned with higher education.

In [20], four empirical studies are presented that possesses characteristics of situated, multimodal and embodied ways of mathematical learning supported by mobile technologies: MULLE (elementary school), MobileMath (lower high school students), Go Math! (family members), mVisible (elementary school). They are all educational experiences that foster collaboration in real contexts outside the classroom, but none of them belongs to higher education.

Regarding m-learning in Argentina, information can be found in [8, 21, 22, 23, 24]. The advantages and disadvantages of using mobile devices in Argentinian elementary and high schools are still being discussed. In most schools, these devices have been banned since they disrupt classroom activities. Published m-learning experiences in Higher Education are scarce. It is worth mentioning the project "Integration of mobile technology to virtual teaching-learning environments" [21, 25]. It delved into the introduction of SMS and the possibility of adapting Teaching-Learning Virtual Environments (EVEA) to support mobile technologies. Although it allowed using the collaborative advantages of such EVEAs, it does not offer the possibility of carrying out positioning-based or context-sensitive activities.

D. MADE-mlearn

Taking into account the theoretical foundations mentioned in paragraphs II.A and II.B, Herrera, Sanz and Fennema [7] have developed a framework to analyse, design and evaluate m-learning experiences. Its main functions are:

- To characterize and identify an experience of m-learning, through its textual description or directly interacting with a specific mobile application.
- To guide the design of a new m-learning experience, both from a pedagogical point of view and as the technological (when involves an application development).
- To evaluate an m-learning experience or project, using the proposed criteria which allow analyzing the elements to be considered in this kind of projects.

MADE-mlearn was made from a socio-cultural ecology approach [4]. It has four analysis axes according to the basic aspects to be considered in the analysis and design of a new or existing m-learning project (see Fig.1):

- Name and Purpose. It encompasses a set of characteristics that identify the experience, scope, objectives and expected results.
- Context. It encompasses a set of characteristics that allow teachers to define the ecosystem of the experience. From the Vygotskian perspective [26], the context could improve the learning process. Both [4] and [4], consider that it is important to study the technological and cultural context in order to design an m-learning project.
- Development and Implementation Mode. It encompasses a set of characteristics that identify the interaction mode of the experience and the learning theories that support it.
- Results. It covers a minimum set of characteristics that allows clarifying the experience results.

These characteristics are grouped into five categories:

- Characteristics of axis Name and Purpose are grouped into Category 1-Identification.
- Characteristics of axis Context are grouped into Category 2-Ecosistem. Sub-characteristics refer to m-learning ecosystem described in [23, 24]. Types of content, presented in section II.A, are included in this category.
- Characteristics of axis Development and Implementation Mode are grouped into categories 3-Interaction Mode and 4-Teoretichal Foundations of Teaching and Learning.
    - Interaction Mode refers to the classification seen in II.A and takes into account the benefits of CSCL seen in II.B.

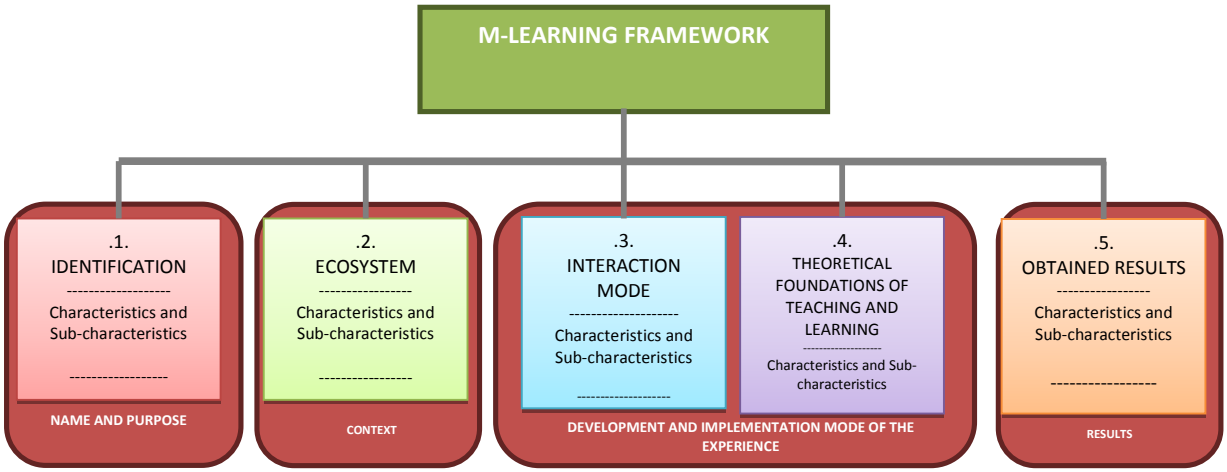

Figure 1. Framework for the Analysis, Design and Assessment of m-learning Experiences (MADE-mlearn).

- Theoretical foundations of learning consider broad approaches such as behaviorism, cognitivism, constructivism [27]. And then, some more specific ones such as: accumulative learning, significant learning, sociocultural learning, and collaborative learning. It is also related to CSCL; mentioned in II.B.

- Characteristics of axis Results are grouped into the category 5-Obtained Results.

Fig. 1 shows the general model of the framework where axes-categories relationships can be clearly seen. In turn, each category has its characteristics which are composed of a set of sub-characteristics.

When the framework is used to analyse an experience, characteristics should be taken into account in order to study that experience. For evaluation, in addition to describing it, each sub-characteristic must be qualified. The framework has a set of ratings and rules that allow the definition of an overall qualification of the experience. Besides, the framework could be used to guide the design of a new m-learning experience.

III. COLLABORATIVE M-LEARNING EXPERIENCE DESIGN

A collaborative m-learning practice was conducted in the postgraduate course Technology Teaching at UNSE. The practice was designed using the MADE-mlearn.

In order to design a new practice using MADE-mlearn it is necessary to describe each subcharacteristic of categories 1 to 4, which make up a total of 84 subcharacteristics. Such description will allow practices with a more technological socio-cultural approach. Category 5 subcharacteristics are obtained once the experience has been carried out.

In this case, the 84 subcharacteristics were completed. This allowed determining the purposes, the deployment context, and the resources of the experience. Table 1 shows the definition of the four subcharacteristics corresponding to the characteristic "Learning and Teaching Approach", Category 4:"Theoretical foundations of teaching and learning".

It is necessary to point out that the main purpose of the experience was to reinforce the learning of the subject *Science and Technology* in the postgraduate course "Technology Teaching", using a collaborative interactive mobile application. And the intended learning outcomes were: significant learning, collective construction of knowledge, better performance on student's qualifications.

TABLE 1. APPLYING MADE-MLEARN TO DESIGN THE EXPERIENCE.

4.1.	**Characteristic: Learning and Teaching Approach**	
Cód	Sub-Characteristic	Description
4.1.1.	Underlying Learning Theories	The experience is identified as a constructivism experience. Besides that, it promotes significant learning based on socio-cultural and collaborative learning.
4.1.2.	Teaching Theories	Teaching is tackled from a collaborative, practical and critical perspective. Theories of scaffolding and situated cognition are also considered.
4.1.3.	Pedagogical and didactical strategies	Taking into account the perspective of "e-activities", the experience is a mixed activity since is not fully developed in an "e" context: preliminary face-to-face training activities are necessary in order to obtain efficient results.
4.1.4.	Type of activities	Educ-Mobile consists of a set of 3 games: 1-Exploring the Scientific, 2-Differentiating Science Technology, and 3- Photo competition. Each game contains questions for each group player. These questions can be individual or not and may refer to: select an answer, enter text, take and upload a picture. Groups need internal interaction, and collective knowledge building to solve the problems. Players use many mobile devices functions and complementary applications to play.
4.1.5.	Key activity	Each 3 games are considered as key activities because everyone involves collaboration. However, the leader has the ability to "Terminate" each game without having completed them.

One of the most relevant issues is that MADE-mlearn allowed the definition of the characteristics and functionalities of Educ-Mobile, which was the starting point of the application development.

IV. EDUC-MOBILE DESCRIPTION

Educ-Mobile is an educational, mobile, interactive, collaborative, and positioning-based application. It is a synchronous game that was designed to promote the creation of collective knowledge about Science and Technology and their relationships. The main goal is for learners to answer questions related to the content in an interactive and collaborative way, and explore a set of previously defined stations.

Players form teams of 2 or 3 members and select a leader. Before starting the game players, teams and leaders are entered into the database of Educ-Mobile. Each player is assigned a username and password to access the application. Fig. 2 shows the "Welcome/Login screen", and Fig. 3 shows the Player Main Screen. The player can start the game or see the score of each player and other options like control the time spent playing.

The application consists of three games. Fig. 4 shows a partial view of the main screen where the player accesses to each game. Games must be played sequentially until the end or when the maximum time (2 hours) is over. Each team member must follow different paths, resolving individual questions that allow access to other group questions that are resolved collaboratively. Points, which are accumulative, are awarded every time an individual or group question is resolved.

After the player logs in, the application activates each game; and the players have to go to different stations to read the QR codes (see Fig. 5).

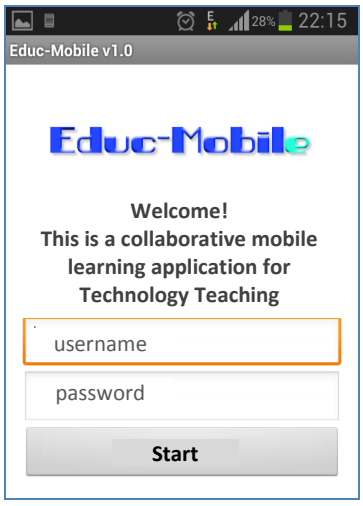

Figure 2. Welcome/Login screen.

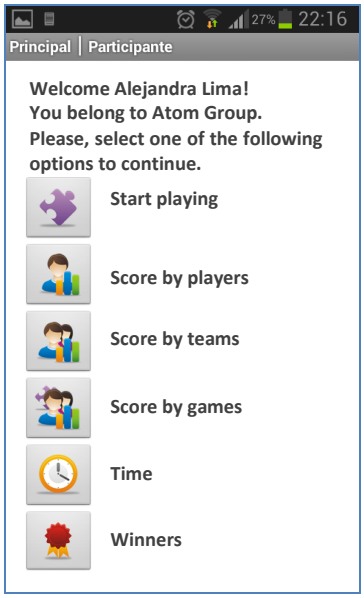

Figure 3. Player main screen.

By reading the QR code, the application checks if the player is in the right station and automatically displays the question to solve. To answer, players can ask the rest of the group or other people using their devices (by chat, SMS, call, etc.). Then, each team receives clues to solve riddles; players need to collaborate to discover the word to be entered. Each leader defines how the team members communicate among them and they are also responsible for entering the responses of group questions. If the group question is successfully resolved, the score obtained by the group doubles. Players on the same team should not meet while the game is running. While playing, the application shows: time spent playing, player scores and team scores.

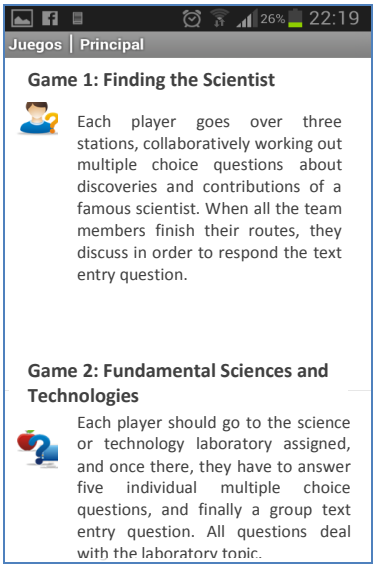

Figure 4. Partial view of Games´s Menu.

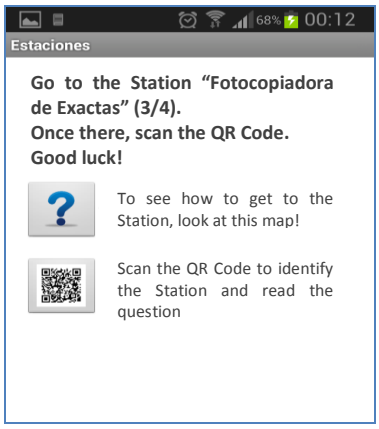

Figure 5. View of Game1's Menu.

Figure 6. Final score screen.

Educ-Mobile runs on Android devices (smartphones or tablets) provided with camera and wi-fi/3G (data network) connection. Barcode Scanner software must be installed too; this is a QR code reader.

The winning team is determined based on the team total score and the time spent playing, following a formula that widely prioritizes score obtained over the time spent.

The results of the formula´s application can be seen by selecting the "Winners" option from the main screen. The final score screen is shown in Fig. 6.

Game 1 is called "Finding the scientist". Each player goes over three stations, collaboratively working out multiple choice questions about discoveries and contributions of a famous scientist. The application indicates if an answer is right and, if not, it shows the correct answer. When all the team members finish their routes, they discuss in order to respond the text entry question. The leader has to input the last name of the scientist related to the question of Game 1.

Game 2 is called "Fundamental Sciences and Technologies". Each player should go to the science or technology laboratory assigned, and once there, they have to answer five individual multiple choice questions, and finally a group text entry question. All questions deal with the laboratory topic.

Game 3 is called "Photography Competition". Each player has to take pictures of hard and soft technologies taking into account some conditions set by the application. If such conditions are met, the group gets an extra score for that game.

V. COLLABORATIVE M-LEARNING EXPERIENCE IMPLEMENTATION

Once Educ-Mobile had been developed and tested, the first collaborative m-learning experience was carried out in the postgraduate course Technology Teaching. In order to implement the experience, the following steps were followed:

1) A survey of the students taking the course and the characteristics of their mobile devices.

2) A survey of the network connectivity at the stations, which served to define the routes of games 1 and 2.

3) The definition of the teams and their leaders.

4) The definition of the assistants during the experience; their roles and activities such as technical coordinator, responsible for Laboratories of Game 2, etc.

5) Student´s training in the use of mobile technology. They made simple practices on how to install Android applications, take pictures and send them by e-mail, set the resolution photographs, connect and disconnect to a mobile network (wi-fi or data network), read QR codes, among others.

6) Communication to students (those involved in the experience with Educ-Mobile and the others): required previous knowledge to carry out the practice.

7) Preparation of scenarios: stations and laboratories.

The day of the practice, students met at 4 p.m. on a Computing laboratory at UNSE and were divided in two groups: those performing the review activity using Educ-Mobile, and those performing the conventional review activity. The former started to play the game while the latter remained at the laboratory. Although in this case the experience restricts mobility to a limited physical space (every station is inside the university central building), the application will be adapted so that it can be implemented in various physical contexts as well as in free contexts, omitting the reading of QR codes.

After logging in, each player started Game 1, "Finding the scientist", and everyone spread following their route. Fig. 7 shows players of different groups in one of the stations.

In Game 2, "Fundamental Sciences and Technologies", each member of the group was appointed to one of the following laboratories: Alpha Laboratory (Computer), Mathematics Room, Physics Laboratory. There they collaboratively solved the corresponding questions.

In Game 3 "Photography Competition", players took photographs of hard and soft technologies (two hard and a soft technology per player) and e-mailed them to the coordinator.

Figure 7. Players of diferent teams in station ARRI, at UNSE.

VI. COLLABORATIVE M-LEARNING EXPERIENCE ASSESSMENT

The assessment of learning outcomes was conducted from a quantitative approach, while student's satisfaction was evaluated from a qualitative perspective. The following steps were carried out:

1) An on-line questionnaire about learning contents was designed to assess learning outcomes. It consisted of a set of 14 multiple-choice questions and 2 open questions; the total score was 100 points. The questionnaire was uploaded in the Moodle Virtual Classroom. The evaluation was performed by every student in the course: the group that did the review using Educ-Mobile (9 students) and the group that did the review by conventional group activities (4 students).

2) Learning outcomes were analysed according to the learning objectives and the student's qualifications. Students who participated in the m-learning experience had better marks than the other group. The dark bar in Fig. 8 shows the average mark of the group that used Educ-Mobile. So the experience met the objectives related to the expected learning outcomes. However, this experience was the first one, and it is necessary to involve more students in order to obtain more accurate results.

3) An anonymous survey was implemented to measure students overall course satisfaction, including a specific section related to the m-learning experience. A questionnaire was designed to assess student satisfaction regarding innovative educational techniques.

The questionnaire was based on the proposal of a research group at the University of Las Palmas [28] which took the SEEQ (Student Evaluations of Educational Quality) form as starting point. The questionnaire was implemented as a Google form, ensuring anonymity in the answers.

A set of ten questions of the questionnaire aimed specifically at collecting opinions about the collaborative m-learning experience. Only 67% of the students completed the survey. On the whole, the response was largely positive and was in favour of the use of mobile devices in collaborative and learning processes (see Table 2).

4) Results were analysed by completing category "Obtained Results" of the MADE-mlearn.

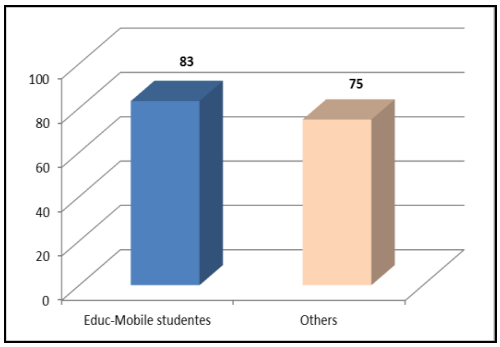

Figure 8. Learning outcomes (Evaluation of contents): average marks of groups that used and not Educ-Mobile.

VII. CONCLUSIONS AND FUTURE WORK

From the analysis of the m-learning experience presented in this paper, preliminary conclusions were obtained about using collaborative m-learning strategies in postgraduate higher education courses. The following topics could be found:

- Postgraduate students mostly use mobile devices (smartphones and tablets) in their everyday life. From step 1, section V.
- In some cases, through these practices, students improve their technological abilities to manage mobile devices and learn how to use services and functions that were unknown to them. From step 5, section V.

TABLE 2. LEARNING SATISFACTION EVALUATION.

Questions ***Scale: 1-Totally disagree 5 –Totally Agree***	**Totally agree**	**Other responses**
The use of mobile devices allowed me to incorporate issues of everyday life to my learning process	100 %	-
M-learning activities allowed me to acquire / improve skills related to the use of mobile devices	83 %	Other 17% said they *Agree*
The use of mobile devices has increased my motivation to learn	83 %	Other 17% said they *Agree*
The use of mobile devices has enabled me to learn everytime and everywhere	83 %	Other 17% manifested a *Neutral response*
The use of mobile devices has benefited collaborative learning	100 %	-
Educ-Mobile experience has allowed me to consolidate my knowledge in Sc. & Tech.	83 %	Other 17% said they *Agree*
Educ-Mobile experience has been motivating	100 %	-
Educ-Mobile experience allowed us to work collaboratively	100 %	-
I would like to repeat Educ-Mobile experience or a similar experience	100 %	-
I would recommend the use of Educ-Mobile to other courses of the curricula	67 %	Other 33% said they *Agree* or manifested a *Neutral response*

- M-learning practices may allow achieving specific learning outcomes. In this case, it helped to strength the acquired knowledge (review) and to build new collective knowledge. From step 2, section VI.
- Collaborative interactive and positioning-based games, e.g. Educ-Mobile, are good tools for collaborative m-learning activities. Students showed great satisfaction when solving problems in a collaborative way (using mobile devices). They also looked very motivated because the application involved them in a competition among groups. From step 3, section VI.
- It is important to plan practices or experiences using a frame based on pedagogical and context issues. In this sense, MADE-mlearn had an excellent performance guiding the design of collaborative activities.

The experience will be implemented in the short term in other postgraduate courses (adapting Educ-Mobile to fit other contents), thus broadening the sample in order to obtain sounder conclusions.

Moreover, from the observation of the assistants, aspects such as the following are considered: the interaction involving mobility from one station to another in a large place (climbing stairs, walking long distances, standing up for long periods, etc.) caused physical exhaustion in people over 40.

From these findings, improving current practices, designing and evaluating new practices, are some of the activities planned to be done by the researchers in the future. One of the most important challenges is to design other m-learning practices based on synchronous games but without fixed paths and without fixed time period. They play from wherever they are.

Extending the practices to elementary and high schools is also projected. Such practices will be carried out using the MADE-mlearn which will certainly be constantly improved.

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