

# A Framework for Educational Collaborative Activities Based on Mobile Devices

## A Support to the Instructional Design

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**Abstract**—In this paper we present a framework (CA-Mobile Framework) for developing educational activities for collaborative learning based on mobile devices. The framework has two main components, the Reference Document component and an API for developing mobile software. This framework is an alternative approach for developing m-learning activities with an integral approach that includes educative and technological aspects through a process model. The framework components, including a process model for applying the framework are described. An evaluation of the value of the Reference Document component through the design of an educational activity was conducted with a group of eight teachers, without previous experience on the design of educational activities based on mobile devices, divided in small groups working independently on the design of the same activity. The design products of each group were compared with a control design developed by authors. The results shown that all groups were capable of replicate the control design using the CA-Mobile Framework

**Index Terms**—API library, collaborative learning, m-learning, framework, instructional design, process model.

### I. INTRODUCTION

With the increase in the use of mobile learning (m-learning) as an alternative for enforcing and providing learning processes, many educators and researchers are interested in taking advantage of its unique attributes and features such as ready-at-hand, ad-hoc wireless networks, multimedia support, moderate and massive storage and eventually, on-the-fly communication and collaboration create several kinds of learning environments that cannot be easily replaced using other types of technology like the desktop PC (Attewell, 2005; Vahey and Crawford, 2002). This has generated the “anywhere and anytime” concept that refers to the capacity that these mobile devices have to access several sources of information or connect with other devices (mobile or not) through wireless connections in practically any place and when needed, even while moving (Rieger and Gay 1997; Wagner 2005; Shen 2008).

Instructional designers have taken these technological characteristics into account to design educational activities based specifically on the use of mobile devices. Due to the diversity of applications and uses of m-learning, different types of these applications have been developed and presented in several reported works, including text based applications like quizzes or class notes (Leung and Chan

2003; White and Byrd 2000), graphical and game based applications (Facer et al. 2004; Milos et al. 2009), video and camera based applications (Yoon et al. 2008; Chen et al. 2004) and recently reality augmented based applications (Spira, D. 2009; Mark, P. 2009; Alapetite, A. 2010).

Moreover, the use of mobile devices has generated growth in several collaborative processes supported by mobile devices. Cell phones, Smartphones and PDAs create new “on-the-go” services (Metcalf and Marco, 2006), allowing people to communicate, negotiate, socialize and learn at the same time in a cooperative and collaborative way. As a consequence, a new model was created under the name of Mobile Computer-Supported Collaborative Learning (Zurita and Nussbaum, 2004; Roschelle et al., 2005). This model begins with the premise of creating collaborative learning situations using mobile devices as the main mediator element.

Therefore, the technology used for supporting formal educational activities could allow active collaboration through real-time chats, shared screens and boards, support for team creation, awareness of participation, and control time of activities such as those described in projects by Benford et al. (2004), Hamid and Fung (2007) and Jarkiewich et al. (2008). This kind of complex interactions require a control of interactions between participants, data and technology, time control and session work integrity, in a synchronous or asynchronous way.

These features are commonly implemented in many collaborative m-learning projects. However, these were designed following one specific approach, technical or educative, instead of an integral approach that uses all the mobile technology features in a didactical way according to a previous instructional design, in order to impact directly on learners. By following a non-integral approach, the result of the activity can have a low impact on learning. For example, a rich technological implementation without an adequate instructional design can distract from the educational objective. While a purely educative implementation can underuse unique characteristics of mobile devices.

Another disadvantage of not using an integral design is that it complicates reusability of didactical and technical resources. This can result in a replication of the development process when development is done for a unique or special case, thus making it hard to use these resources in another activity. Also the design process cannot be documented and organized properly.

To achieve an integral design of activities, it is necessary to take into account both educational and technical

aspects throughout the complete development process including concepts of motivation (Cheng and Yeh 2009), learning experience and objectives (Parson et al. 2007), new models focused on just-in-time, just-in-place models (Metcalf, D. 2006) and different learning activity levels (Wang et al. 2004). In the same way, collaborative activities have special requirements which will be considered from instructional design to software development. For example, a previous experience with collaborative tools (Huang et al. 2009), Peer-assisted learning procedures (Tsuei 2009) and social aspects such as positive interdependence, face-to-face interaction, individual accountability/personal responsibility and teamwork skills (Smith et al. 2005).

Although these aspects are not always clear at the beginning of the design, they are an important part of the activity and it is highly recommended to describe them in greatest detail. This is important to facilitate the implementation of all functions associated with these features, both in software and didactic scripts. Also, we consider that these characteristics impact in some degree on the success or failure of the activity in a real educational scenario.

Taking these aspects into account, we developed a framework for developing m-learning activities with an integral approach that includes educative and technological aspects. The framework contains two main components; a Reference Document component, and a specialized Application Programming Interface library (API) for the development of mobile software, including a process model for applying the framework. The propose of this paper is to show the results of an evaluation of the Reference Document component (the first component of CA-Mobile Framework) realized by a group of eight teachers, in order to know their assessment of the usefulness and clarity of this component, and show evidence that the Reference Document component provides a structured and organized route to create the instructional design of activities based on mobile devices.

## II. CONSIDERATIONS FOR DESIGNING COLLABORATIVE M-LEARNING ACTIVITIES

The creation of a learning environment mediated by computers, where students can work together to reach shared goals, is a complex task from a technological and educational viewpoint. From a technological approach, the learning activity can use one or several interaction mechanisms as of direct communication channels (verbal, text, audio or video), shared places (boards, screens and documents), awareness of collaboration (presence and status rosters, definition and description of roles and status of the common goals), and control and monitoring of course tasks and student's learning paths. Moreover, from the educational perspective, the different skills of students as well as the environmental conditions where the activity will be developed are factors that increase its complexity. All educational activities that include the use of technology as an active actor require a differentiated educational design compared to traditional face-to-face educational activities that involve only teacher and students (Patten et al., 2006). In this sense, there exist several factors that the instructional designer should take into consideration in activity design; factors such as type of technology, physical space, use conditions, setup time, as well as training of participants for the use of technology. These, are just

some of the factors that lead the design and should be considered when developing the activity in order to obtain successful results. They can be seen as non functional requirements according to Avellis et al. (2005) and Mostakhdem-Hosseini (2009).

In the same way that the characteristics of the desktop PC impose certain criteria and constraints for activity design, the use of mobile devices imposes its own criteria and constraints associated with its mobility and technological restrictions. Unlike the desktop PC, mobile devices have small screens, moderate storage capacity and reduced keyboards. These constraints are in some way compensated with their capacity for portability, mobility, support for multimedia, and ease with which to create ad-hoc networks between two or more devices for example, using Bluetooth, WiFi o IrDA (Cruz-Flores and López-Morteo, 2008). All of these characteristics should be considered when activities based on mobile devices are designed, even if the activities require the use and interaction of mobile devices and desktop PCs at the same time.

Thus, from an instructional design point of view, and considering the professional profile of the activity designer (experience like teacher and experience designing activities supported by computers), it seems to be necessary to have within his capabilities a huge knowledge about the potential and unique features of mobile devices, in order to determine the role of technology on the activity execution. As an aid to identify both humans and technical needs by the instructional designer, we present a classification of the needed skills, also known as pre-conditions that this professional has to develop in order to create reliable instructional designs based on the use of mobile devices. The categories of the pre-conditions for the design of these educational activities can be classified in three categories;

- Human. Considers all skills and knowledge needed to execute tasks described in the activity (e.g. experience using cell phones).
- Technical. Includes all the processes associated with technology like installation, configuration, and setup of the systems that participate in indirect tasks (supporting tasks), but are not part of the main educational activity (e.g. deployment of mobile software into devices).
- Organizational. Considers all tasks for the organization of participants before the main educational activity. This category also contains the teacher's guide for the development of the activity, as well as the administration of the computational resources (mobile devices and/or PC) needed for the execution of the activity (e.g. grouping by teams or by peers).

If these elements are considered during activity design, then the contexts for the activity can be clearly defined, because they are pre-conditions that, if not specified and considered, can significantly and negatively affect activity execution. We believe that this situation can happen because the pre-conditions are not optional and serve to create the environment where the activity will take place, and compliance with it will be necessary even if they are not considered explicitly in the design. These activities are intended to achieve their pedagogical objective through the execution of focused group tasks.

For this work, the actions like start of interaction, type of interaction, type of communication, duration of interac-

tion, and definition of roles could be used by any collaborative educational activity that uses mobile devices. All these considerations served to organize and develop the components in the framework according to their educative or technical functionality.

### III. CA-MOBILE FRAMEWORK FOR DESIGNERS AND DEVELOPERS

The interest on using mobile devices in the educational environment is not new and several works have been reported by specialized literature in the last 10 years. However, the design process for developing software for mobile devices with an educational approach has not had a substantial growth in the use of tools and programming languages. The creation of educational activities based on these devices is very dispersed. As we mentioned previously, some works are oriented mainly towards the educational context, while some others privilege the technological aspects. We believe that the aspiration of achieving the educational objective supported by technology can be done by merging features from these two fields while taking into account that the primary need is to support the learning process using mobile devices.

We propose an integral framework (CA-Mobile Framework) to support the process of designing collaborative educational activities based on mobile devices including educative aspects and the development of software to support these activities.

The CA-Mobile Framework (see Fig. 1), defines all the mechanisms necessary to support the development process of the educational activities that we are interested in. The framework artifacts are a set of documents for the specification of didactical requirements, functional requirements, and a specification/adaptation of an instructional script of activities which was adapted to consider the use of mobile devices. Moreover, the framework also provides a set of application programming interfaces (CA-Mobile API), to create and implement features in software to mediate the activity. This API contains reusable software components to implement the following functionalities: communication, turn control, textual message exchange, textual and graphical resource management, and user interface management.

The CA-Mobile API was developed for the Java programming language and includes two versions of the API, the SE edition for desktop applications and the ME edition for mobile devices with JME support. The two versions were required because the CA-Mobile Framework was designed to include mobile devices with optional interaction with desktop PCs (e.g. a chat application between cellular phones and PCs.) in the same activity. The API versions share many features like Bluetooth communication or floor control. However, others are exclusive of the ME edition (e.g. Camera control or canvas graphics control). These components also, allow controlling the execution of the process stages and the products resulting from each one. All the components of the framework are grouped by functionality and are detailed in section five of this paper.

Due to the holistic approach of the framework with respect to the educative and technical aspects, the CA-Mobile Framework can be analyzed from two viewpoints; educational approach and technological approach, which are described below.

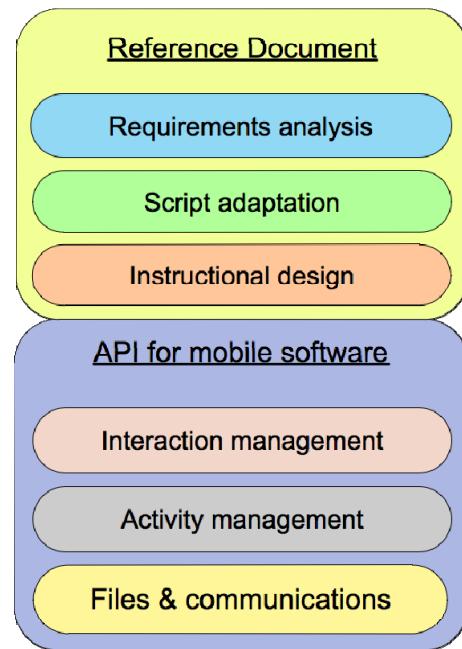


Figure 1. CA-Mobile Framework components overview grouped by educative and technical functionality.

### IV. EDUCATIONAL COMPONENTS

One predominant factor in instructional design is the educational foundation of activities, thus the CA-Mobile Framework contains several components for describing and specifying these pedagogical features grouped as follows:

#### A. Instructional Design

This component acts as the starting point of the development process. It contains all elements (documents, guides and reference videos) for supporting the description of activities in didactical terms. External associated requirement are included too.

- **Activity description.** - Provides a structured way to describe educational activities, and serves as a basis for the beginning of the development of the process activities.
- **Description of external actions associated with the educational activity.** – Describes an additional process necessary to accomplish the objective of the activity, such as forming student groups, task explanation, setup of mobile devices and desktop PC, as well as software configuration.

#### B. Script adaptation

The Framework supports the process of adapting the original script to several forms. It also includes reference guides regarding the use of these forms. Both elements: forms and guides are part of the Reference Document.

- **Didactical script adaptation.** - Modifies and adapts the original script, to include the use of mobile devices and/or PC Desktop, specifying the moment where these devices will be used, and the actions that will be supported by these devices.
- **Specification of human, technical, and organizational considerations.** - This specifies the preconditions that must be fulfilled before the activity

takes off. This component is associated with the description of external actions that are in turn associated with the educational activity. It is also related to the actions that are necessary for the execution or the repetition of the activity, such as user training, connection between devices. Tasks related to previous coordination like grouping students by team or special classroom conditions are described here.

- **Forms use guide.**- Provides a reference to the forms and templates. It is used by other components of this reference document to describe in detail the fields within each document and their possible uses, as well as an analogy of concepts in the cases where it applies.
- **Specification of associated roles inside the activity.**- Determines the actions and responsibilities of all the roles and resources involved in the execution of an activity, like the student, the teacher, mobile devices and the software, describing the characteristics and skills of each one.

#### C. Instructional Design

- **Describes the stages of an activity through use cases.** - Describes through use cases, all the detailed actions to be executed by each role in a specific stage of the activity. These descriptions will be the basis for the final script of the activity.
- **Specification of functional requirements.**- Extracts from use cases, those requirements that must be covered by mobile and desktop software, excluding human coordination and negotiation tasks (non functional requirements).
- **Association of requirements vs. API components.**- Makes an association between each requirement described in the specification of functional requirements and the selected API components in order to know which software component will be used to implement the required functionality.

Each one of these components is used by the instructional designer to fill out or complement a structured document in the framework, either an activity description, use cases or requirements document.

### V. TECHNOLOGICAL COMPONENTS

Once the requirements are specified, the next task is to create software to support the activity that follows the requirements associated with technology. Several software components were added as part of CA-Mobile Framework to support the development of mobile software using the Java programming language and JME libraries. The components simplify the implementation of these libraries and the resulting software can be executed in any device with JME support. These components are grouped in an API and are described below.

#### A. Interaction management

This part of the API includes components to build user interfaces such as capture forms, graphics resources manager, and camera control.

- **User interface control.**- Implements the components to create menus and capture forms, as well as persistent look-and-feel in several mobile devices and desktop PC.

- **Video and camera control.**- Implements the necessary components to handle photo and video camera of mobile devices.
- **Images control.**- Implements the components to handle graphics contents on the display like a single image or with textual description.

#### B. Activity management

This part of the API contains components to begin the interaction between participants, handle work sessions, as well as manage turn taking and shared resources.

- **Peer administration.**- Implements the mechanisms to manage the start of interaction between peers through mobile devices and desktop PCs.
- **Session control.**- Implements the mechanisms to start a collaborative work session between two or more peers through mobile devices and a desktop PC.
- **Turn control.**- Implements the components for the management of turns between participants in a collaborative work session.
- **Floor control.**- Implements the components for the management of shared resources, such as screens and message logs.

#### C. Files and communications

This includes components to establish wireless communication, handle messages exchanged between peers, and file exchange management.

- **Communications.**- Implements the mechanisms to establish wireless communication between mobile devices and desktop PCs.
- **File management.**- Implements the components for the management of files exchanged between mobile devices and a desktop PC.
- **Message control.**- Implements the mechanisms to manage the exchange of messages between applications and users, message handling, and visualization of textual messages.

These components, the reference document and the API for mobile software, work together in the development process of educational activities. However, these components by themselves do not define how and when the components will be used in the development process. For this reason, a process model was created to support the use of the forms, guides and video references, as well as API components of CA-Mobile Framework. This model presents a workflow of the tasks involved during development process. All details of the model and the relationship between components of the framework are described in the next section.

### VI. PROCESS MODEL OF CA-MOBILE FRAMEWORK

The process model created to guide the use of the framework components is divided into five stages, which define the roles included in the development process, the artifacts, and the products at each stage. The actors that perform the roles need some degree of experience using mobile devices and are classified as instructional designer, teacher or content expert, and programmer. The responsibilities and tasks of these roles are described in Table 1.

TABLE I.  
ROLES IN THE PROCESS MODEL

Role	Responsibilities
Instructional designer	Is responsible for the specification of the activity in terms of structure, learning style, educational objective, specifying the activity requirements in terms of CA-Mobile Framework and adapting the didactical script to include the use of newly developed mobile software.
Teacher or content expert	Is responsible for suggesting and choosing the contents that will be included in the activity, participation in the definition of the educational objective, and participation in the final product evaluation in terms of the original didactical requirements.
Programmer	Specifies, in conjunction with the instructional designer, the requirements of the software in functional terms, chooses the API components that will be used to satisfy the requirements, and builds the software for mobile devices and, if it is the case, for Desktop PC. Participates in adapting the didactical script as well as in final product evaluation.

In addition to the roles, the process model (see Figure 2) proposes six main stages to develop the educational activity. In the same way, the model specifies each of the artifacts (documents and tools) used as inputs and outputs of each stage.

#### A. Stage 0: Instructional design

This stage describes, in a general way, the activity in didactical terms including objectives, skills fostered, organization requirements (previous to activity execution, including any technical requirements), estimated time, and preliminary and general script for the activity. The result of this stage is a form (part of CA-Mobile Framework) where the activity is specified including typical data (name, time, audience) and a preliminary didactical script specifying the use of mobile devices inside the activity.

#### B. Stage 1: Characterization and specification of activity requirements

At the beginning of this stage, the first requirements specification of the activity based on a preliminary script is written, associating concepts of the instructional field to functionalities that will be performed by both the participants of activity and mobile technology. At the end of this stage, a document is created where all task and organization requirements are specified in coordination terms, as well as features that will be mediated by mobile devices and the desktop PC. All tasks defined in the instructional design stage are described using a special use case format, which is part of CA-Mobile Framework. Although some tasks won't be supported by mobile devices such as human coordination or verbal negotiations, all must be described using these formats.

#### C. Stage 2: Association of requirements vs. API components

Once all tasks are described, the functional requirements are extracted from the forms (only the ones supported by mobile devices or desktop PC). A selection is made of the API components that will be used to build mobile software to cover these functional requirements of the activity, taking into account that the functionality of

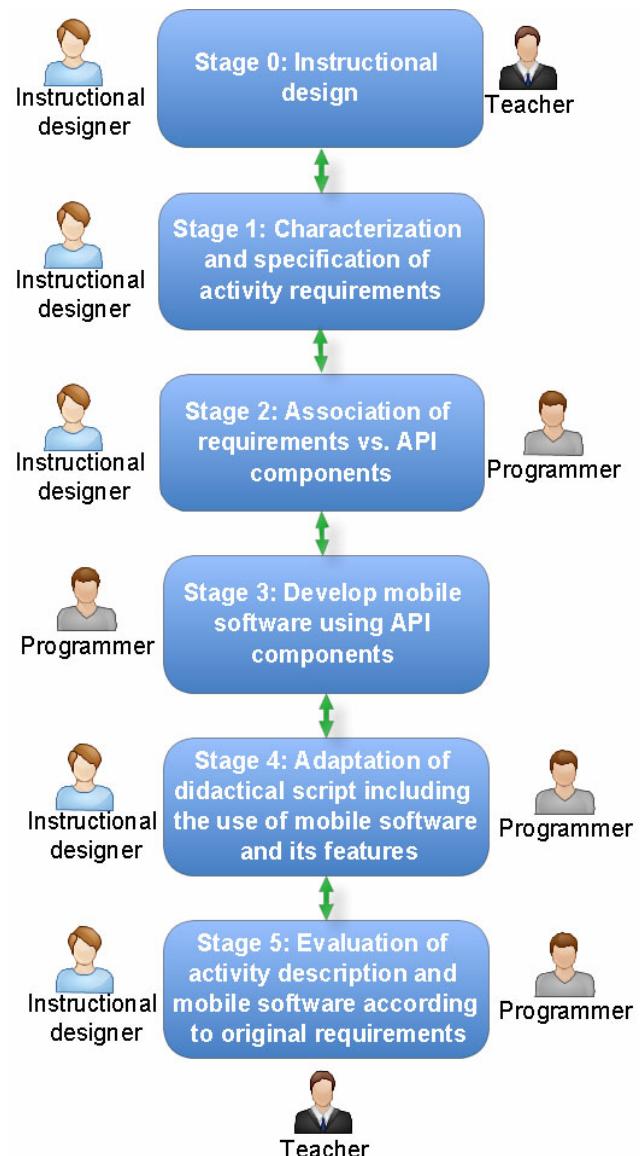


Figure 2. The six stages used in the process model of CA-Mobile Framework including the roles involved in each one.

the selected components corresponds to one or more requirements. For this, the Requirement and components specification document, part of CA-Mobile Framework, is used. This document presents the relation between a functional requirement and the selected API component that covers it.

#### D. Stage 3: Development of mobile software using API components

The mobile software to support the activity is developed in this stage covering all functional requirements using pre-selected API components specified in the requirements and components specification. Another external tools might be used like a specific API, e.g. for a specific rich graphical interface, or extended API for integrating a Desktop PC using Bluetooth communication, e.g. a Bluetooth library for PC. A functional prototype of software is the result of this stage. In some cases, the result is one version of software for mobile devices and a different version for Desktop PC.

*E. Stage 4: Adaptation of didactical script including the use of mobile software and its features*

In this stage an adaptation of didactical script is performed, taking previous scripts extracted from use cases specified in the characterization and specification of activity requirements stage. This adaptation must include the use of mobile software as part of tasks that require it and defines the external requirements associated with the use of mobile devices or Desktop PCs, for example user training or pre-configuration of software and devices. Once finished, the adapted didactical scripts are extended in order for all tasks of each activity to include details about the use of software and times for each task.

*F. Stage 5: Evaluation of activity description and mobile software according to original requirements*

At the end of the process, the didactical scripts and software are evaluated in terms of the functional requirements specified. Necessary changes are made both in the didactical script and mobile software, maintaining the consistency of the relation between the different parts of the activity. Both the didactical script and software are provided to test the complete activity including performing the necessary actions of resource control and coordination of participants.

In this way, the process model proposes a structured way to develop educational activities maintaining at all times a control by stages, generated products of each one, roles and responsibilities. Moreover, the model provides a reference about the stages that integrate the complete development process of activities based on mobile devices, from an integral approach of educational and technological aspects. The products generated could be used to design a new activity or to extend the original.

## VII. REFERENCE DOCUMENT EVALUATION

In this paper we present a qualitative evaluation of the Reference Document component focusing on the instructional designer's perspective, in order to know the assessment about the usefulness and clarity of forms, guides and training videos in the design process. The CA-Mobile API is being evaluated and validated in another study with a technical approach to found evidence of usability, completeness and simplification that the API provides for the development of mobile software.

This evaluation was carried out through an experiment with education professionals, in order to test the forms, guides and reference videos of the Reference Document with one exercise; at the end of the exercise they answered a questionnaire about the use of these artifacts. The main propose of this evaluation was to capture the perception of teachers of the usefulness of the Reference Document of the CA-Mobile Framework for design of educational collaborative activities based on mobile devices from an educational perspective.

The evaluation was performed with a group of eight teachers; all of them are postgraduate students of a science education program, of which 75% have a college education in science education and the remaining 25% in mathematics and engineering.

Usefulness was evaluated by an analysis of coincidence of description activity forms, comparing each form with a

pre-designed form. Later a questionnaire about the artifacts (forms and guides) was applied to all participants.

Thus, the evaluation was divided in two parts. In the first part, teachers were exposed to one experimental scenario presented in a video, which described an activity based on mobile devices and their associated process. We also showed all the activities related to the setup of the mobile devices and desktop PC. In the second part, participants had to create the preliminary instructional design of the activity and all associated process of the observed scenario, material organization, devices configuration, and task coordination using the forms and guides of the Reference Document component of the framework.

The video included the tasks preformed before the execution of the activity, in order to identify those processes related to setting up and deploying software in mobile devices, as well as forming teams including a record of the mobile devices that would be used. All these processes were performed on the teacher's platform. Subsequently an example of how students perform the activity inside and outside the classroom was presented. After that, the teachers answered a questionnaire about the usefulness of artifacts used (see figure 3).

*A. Description of the educational activity*

The activity used in the scenarios with participants was "Recognizing geometric shapes" which was developed and adapted to use mobile devices by Cruz-Flores and López-Morteo (2009). The main objectives of this activity are to develop a better understanding of shapes as a whole, to identify the parts of a shape or identify full shapes inside a physical environment, to understand how shapes differ and how they are alike using appropriate vocabulary during class discussion, similar to activities presented by CETConnect (2009), Instructor WEB(2009) and Learn, N. (2004), which proposes the same educational objective, but do not consider the use of mobile devices.

This activity was developed using the CA-Mobile Framework and applying the process model, where the instructional designers specify the educational purpose of the activity and how the use of mobile devices will provide support for this activity. After that, the programmers developed the software in two versions: Mobile and PC. In this case, both versions of software perform complementary tasks in the same activity. At the end, the soft-



Figure 3. Teachers during Reference Document component evaluation: Working in teams to describe the educational activity.

ware and didactical scripts were evaluated and validated by teachers, instructional designers and programmers in functional terms. This activity was used as an example of how to introduce participants of this evaluation into the design of educational activities based on mobile devices. A description of the “Recognizing geometric shapes” activity is detailed below.

Four team members (mobile peers) will explore the physical environment near the school in search of any building or parts of a building which have at least one of the basic geometric shapes: circle, triangle, square and rectangle. With the mobile device, they will take pictures of the buildings they found and send them to the other team members (local peers) who are working on the Desktop PC. These peers will receive the photos and they will classify them according to their geometric shape. Once identified, local peers will build a brochure with the photos, and the name of the geometric shape that it represents.

Team members can also communicate with each other through an integrated chat between mobile device and PC. It is important to communicate in case another photo is needed, or to communicate that a geometric shape is missing. At the end of the activity, all brochures made by each team are presented and discussed in class

The descriptive information that teachers should describe was composed of; Activity name, Date, Author, Version, Description, Educational/didactical objective, Skills fostered, Audience, Requirements, Estimated time, Development, Roles, Deliverable product and Required material by team.

### B. Evaluation

At the end of the exercise, the three teams of instructional designers delivered their own detailed description of the activity. The description made by each team was compared against a pre-defined master description in order to determine the degree of coincidence between the descriptions of the teams and the original version, finding similarities and differences in all core fields. These coincidences allow us to see whether the fields and structure of the forms and the guides are enough to clearly describe each part of the activity.

The results of the three teams were evaluated with regards to interpretation of the text in each field, and not in terms of words and concepts used. The classification of range of values for this analysis of coincidence is the following:

- High.- Level of coincidence with the original from 65% to 100%.
- Medium.- Level of coincidence with the original from 30% to 65%.
- Low.- Level of coincidence with the original from 0% to 30%.

It is important to highlight that the levels of coincidence were analyzed document by document in order to interpret written ideas in the artifacts by each team. Using these parameters, the result of the analysis of all the descriptions of each team is detailed in Table II.

These results show that, in spite of the variations, the three teams made a description of the activity that was similar to the original. The case with a smaller degree of coincidence was team one (with two teachers) in the field: estimated time and development. Based on the observa-

TABLE II.  
ANALYSIS OF COINCIDENCE. HIGH (0%-30%), MEDIUM (30%-65%) AND LOW (65%-100%)

Field	Team 1 (two people)	Team 2 (three people)	Team 3 (three people)
Description	Medium	High	High
Educational/didactical objective	High	High	Medium
Skills fostered	High	Medium	High
Audience	High	High	High
Requirements	High	High	High
Estimated time	Low	Medium	High
Development	Low	High	High
Roles	Medium	High	High
Deliverable product	High	High	High
Material by team	High	High	High

TABLE III.  
RESULTS FOR EACH ITEM IN THE QUESTIONNAIRE USING MEDIAN

Item	Def. yes (1)	Prob. yes (2)	Undecided (3)	Prob. no (4)	Def. no (5)	Median
1	7	1	0	0	0	1
2	7	1	0	0	0	1
3	8	0	0	0	0	1
4	5	3	0	0	0	1
5	7	1	0	0	0	1
6	8	0	0	0	0	1
7	3	4	1	0	0	2
8	1	7	0	0	0	2
9	7	1	0	0	0	1
10	7	1	0	0	0	1

tions of the experiment, we believe that these differences could be caused by the viewpoint of one participant who was a teacher with many years of instructional experience who considered that the estimated time should be higher than proposed in the original design and likewise considered that the development of the activity should include aspects related to the delivery of assigned equipment and how the teacher obtains the final evidence of the activity.

At the end of the first part of the experiment (activity description), a questionnaire with ten closed questions and two open questions was applied to participants in order to obtain a general opinion regarding the artifacts. Through the use of this questionnaire we expected to observe the assessment of the participants regarding their experience using the Reference Document artifacts. At the end, the results were analyzed using a median and the results are presented in table III. The items of questionnaire are:

1. Could you use all artifacts (forms, guides and videos) of the Reference Document?
2. Is the purpose of each document clear?
3. Are artifacts of reference and training (forms, guides and videos) useful?
4. Are the names of those forms appropriate and refer to their use?
5. Do the field names correspond to their content?
6. Is the vocabulary used in the artifacts adequate?

7. Do you consider the guides that accompany the forms useful?
8. Is the structure of the forms appropriate?
9. Do the forms help to specify the use of mobile technology as part of the activity?
10. Is the Reference Document useful for defining and describing activities using mobile technology?
11. Describe any suggestion of change, adaptation and / or extension of the artifacts presented.
12. What is your general assessment of the Reference Document of the CA-Mobile Framework?

The responses for the first item indicate that participants used all artifacts (Definitely yes=87.5%, Probably yes=12.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%). This results show that most participants used all artifacts at least once during the description activity process (Median=1).

The second item is related with the clarity of the objective of each artifact (Definitely yes=87.5%, Probably yes=12.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%). This means that participants understand the objective of the artifacts used during the design process (Median=1).

According to the third element (Median=1), the assessment about the usefulness of the artifacts shows that all participants found these resources useful (Definitely yes=100.0%, Probably yes = 0.0%, Undecided = 0.0%, Probably No=0.0% and Definitely No=0.0%).

The fourth item is related to the names of each artifact and whether it refers to its use (Definitely yes=62.5%, Probably yes=37.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%). This indicates that the names assigned to the artifacts are adequate, although they could be clearer. In this case, some participants suggested name changes that would be more representative of the content of each document (Median=1).

Regarding the fifth element that concerns the congruence between the fields in each form and their content (Definitely yes=87.5%, Probably yes=12.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%) the results show that the majority of participants consider the names and the described content congruent (Median=1).

The sixth item refers to vocabulary used to define both the fields and their descriptions in the guides, in order to know the assessment of participants regarding the words used and their meaning in the pedagogical field (Definitely yes=100.0%, Probably yes = 0.0%, Undecided = 0.0%, Probably No=0.0% and Definitely No=0.0%). This mean that the vocabulary used is representative for participants (Median=1).

The seventh item refers to usefulness of the guides that accompany the forms (Definitely yes=37.5%, Probably yes = 50.0%, Undecided = 12.5%, Probably No=0.0% and Definitely No=0.0%). These results show that the guides were used as support to fill the forms. This item shows a different median value (Median=2), because the participants found all the guides useful, whoever they thought that these guides were not essential. This opinion may be caused by experience level of participants with regard to instructional design. In this evaluation all participants are

professional educators and were selected for their skills to describe educational activities.

The eighth element measures the organization and structure of the forms (Definitely yes=12.5%, Probably yes = 87.5%, Undecided = 0.0%, Probably No=0.0% and Definitely No=0.0%), the responses show that teachers though the contents of the forms are suitable, although their structure and organization was not the most appropriate (Median=2).

The ninth item determines whether the artifacts used facilitate the use of mobile devices and desktop PC as part of the tasks of an activity (Definitely yes=87.5%, Probably yes=12.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%). This means that most of the participants found the contents inside artifacts are directed to describe and include the use of mobile devices like a part of the activity (Median=1).

The tenth item questions the usefulness, in general terms, of the Document Reference to design educational activities based on mobile devices from the instructional perspective (Definitely yes=87.5%, Probably yes=12.5%, Undecided=0.0%, Probably No=0.0% and Definitely No=0.0%). This means that teachers believe that the artifacts are useful to describe this type of activity (Median=1).

Finally, the last two questions gave a textual assessment about the Reference Document, which show that participants found these artifacts useful as support tools to develop the instructional design of activities based on mobile devices. Also, teachers made general recommendations regarding the structure of the contents, and the vocabulary that might be useful for the fields.

Once all responses from the participants were analyzed, it was possible to summarize the following points:

- Instructional designers consider that the Reference Document is useful as a support tool to design educational activities that include use of mobile devices as a core part of the activity.
- The contents inside the forms cover all the information needed about didactical and pedagogical aspects of the activity to generate the didactical scripts and to support the software development process.
- The guides and reference videos are a good complement to the forms of specification of the activity.

## VIII. CONCLUSION

When mobile devices are used to support educational activities, it is possible to create an interesting and attractive learning environment for students. However, the characteristics that this technology imposes for its use in the classroom, imply that the development process of activities based on mobile devices must take into account several features from pedagogical and technological approaches, such as the definition of the educative objective, the creation of all coordination tasks, the specification of the role of mobile devices in the interactions between participants, and the definition of a didactical script to include the use of mobile devices and desktop PCs as an important part of the activity in order to reach the educative goal proposed.

Group activities require a special design because they involve a collaborative learning model, which is different from an individual learning model. These differences im-

ply that mobile technology act as a dynamic actor to mediate the interactions between participants, manage resources and products, permit the negotiation, coordination and socialization process through mobile devices.

The CA-Mobile Framework presented in this paper offers several elements to develop educational activities based on mobile devices, through its two main components: the Document Reference and the API for mobile software. These components provide support at several levels of the development process. This framework includes a process model to coordinate the application of its different elements in a structured way, allowing the definition of user roles for those involved in the development of the educational activities based on the use of mobile devices. In addition, the process model helps to maintain control of the execution of the stages, indicating the order of execution and the inputs and outputs required during the process.

Because of the nature of the framework, it is possible to evaluate it from two main approaches: pedagogical and technological. This paper showed an evaluation from a pedagogical approach where the usefulness of the documental reference of CA-Mobile Framework was evaluated and the results gave evidence of that it is possible to describe entire educational activities based on mobile devices and make an instructional design using the artifacts provided taking in account the following elements: advantages of mobility and portability of devices, use of wireless communication to share real time information and resources, and tasks performed beforehand to deploy and install software.

The results show that using the guides, forms and videos of the Reference Document allowed the replication of the procedure for describing and defining activities, obtaining similar results to the original design, the assessment of the participants in the experiment gave evidence that the Reference Document component provides a structured and organized route to create the instructional design required by process model in stages 0, 1 and 2. These stages provide the foundations for the entire development process. The table 4 shows that the activity description of each team has a high coincidence grade about the original description. Team number one reported a 60% of high coincidence, 20% of medium coincidence and 20% of low coincidence. Team number two reported a 80% of high coincidence and 20% of medium coincidence and the last team reported a 90% of high coincidence and 10% of medium coincidence. The three teams described all elements of the activity using the Reference Document component's artifacts as reported in the questionnaire. The results allowed us to determine that the Reference Document of CA-Mobile Framework provides support to instructional designers to create a consistent design of collaborative educational activities based on mobile devices through the use of the forms, guides and video references of Reference Document. The forms description of activity, use cases and description of requirements filled out by instructional designers, will be used by mobile programmers to develop the software for the activity based on the specified requirements.

## IX. FUTURE WORK

In order to have an integral evaluation about CA-Mobile Framework, we require an evaluation of the API

component for developing mobile software. This evaluation will be complementary to the evaluation presented in this paper. For that, an evaluation of CA-Mobile API in terms of usability and completeness is being performed. Taking a technological approach, the API will be evaluated as a software component applying metrics like the cognitive dimension framework (Clarke and Becker 2003). To perform an evaluation from a technological approach, it is necessary to create a complete educational activity based on mobile devices. This will allow the evaluation of the complete development process from the educational and technological approach, including the last stages of the process model, which can only be evaluated with a complete final product.

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