Future Generation Computer Systems 34 (2014) 124–137

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Using the cloud to develop applications supporting geo-collaborative Situated Learning

Gustavo Zurita[a], Nelson Baloian[b,*], Jonathan Frez[c]

[a] Management Control and Information System Department, Faculty of Economics and Business, Universidad de Chile, Diagonal Paraguay 257, RM, Santiago, Chile

[b] Department of Computer Science, Universidad de Chile, Blanco Encalada 2010, RM, Santiago, Chile

[c] School of Informatics and Telecommunication, Universidad Diego Portales, Vergara 432, RM, Santiago, Chile

HIGHLIGHTS

- A general architecture for developing geo-collaborative applications is proposed.
- Two applications developed following this architecture are shown.
- A framework which supports the development of applications was developed and tested.
- The benefits of using this architecture and the framework are shown.

ARTICLE INFO

Article history:
Received 11 February 2013
Received in revised form
30 September 2013
Accepted 4 October 2013
Available online 12 October 2013

Keywords:
Mobile learning
Geo-collaboration
Situated Learning
Cloud Services
Software architecture

ABSTRACT

Situated Learning stresses the importance of the context in which learning takes place. It has been therefore frequently associated with informal learning or learning outside the classroom. Cloud technologies can play an important role supporting this type of learning, since it requires ubiquitous computing support, connectivity and access to data across various scenarios: on the field, in the classroom, at home, etc. In this paper we first present the situated learning theory and how we can take advantage of services offered by Cloud Computing to implement computer applications implementing learning activities based on this theory, providing pertinent geographical information and discussion boards. Next we propose a software architecture schema which can be used as a basis for integrating existing cloud services into new applications supporting learning activities. Then we present two examples developed with this approach with its viability and advantages. These are discussed in the concluding chapter.

1. Introduction

The Situated Learning theory states that learning requires theoretical concepts learned in the classroom to be linked to practical situations in authentic contexts where they can be applied [1,2]. The way in which humans learn implies practicing the concepts acquired in theory [3]. Moreover, teaching and learning activities involving conceptual knowledge (learned inside a classroom), and practical implementation (in real situations) are not only complementary, but also feedback each other in a process of ongoing and increasing interaction.

Recent advancements in mobile, wireless and positioning technologies, combined with contextual computing, provide an opportunity for curricular development that may take advantage of these devices for supporting different aspects of learning and teaching [4]. Mobile and wireless technologies allow interaction with the real world in new ways because computational power and interaction are available outside the classrooms limits. Mobile technologies combined with content access virtually anywhere and anytime, allow learners to gain new learning experiences in a variety of situations beside the classroom itself [5,6].

Nowadays, new learning situations have been proposed that are marked by a continuity of learning experiences across different learning contexts. Students, individually or in groups, carry out learning activities whenever they want in a variety of situations and that they switch from one scenario to another easily and quickly. In these learning situations, learners are able to examine the physical world by capturing sensor and geo-positional data and conducting scientific inquiries and analyses in new ways that incorporate many of the important characteristics suggested by situated learning.

In the literature, we can see a growing number of applications developed to support collaborative learning according to the

* Corresponding author. Tel.: +56 2 29780652.
E-mail addresses: gzurita@fen.uchile.cl (G. Zurita), nbaloian@gmail.com, nbaloian@dcc.uchile.cl (N. Baloian).

0167-739X/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.future.2013.10.007

situated learning theory, which also make use of geo-referenced information. These applications have in common implemented communication mechanisms that allow learners interact with one another and at times with the teacher in synchronous or asynchronous ways in order to work collaboratively across various learning situations; in locations and devices. However, these applications are seldom related to the concepts of Cloud Computing, nor take advantages of what this paradigm can offer. Cloud Computing is about ubiquity, reliability, scalability and lowering costs, which matches the requirements for applications in which users will be using a variety of devices, in different settings and scenarios.

We understand Cloud Services as the functionalities that Cloud Computing may offer to its users which may be accessible using an internet website or by using an API, thus including the services as part of a new application. According to our previous experience developing applications for supporting learning activities and analyzing others' experiences through the literature, we see a real opportunity to take advantage of the available services in the cloud and systematically use them for developing applications supporting learning activities. We especially consider those, which make intensive use of geographical information and include the discussion as an important part of the learning activity. Applications with these characteristics can often be associated to the Situated Learning theory [3]. These functionalities, geo-location and discussions, are implemented as Cloud Services by various service providers: for example, geo-location is provided by Goggle Maps, Openlayer and Mapserver. Discussion forums are implemented through various microblogging sites like Twitter and Facebook, which have been successfully used for supporting discussions in learning scenarios. Therefore we think that developers of applications supporting learning activities based on the Situated Learning theory can take advantages of services provided by the cloud in order to implement them with less effort and more reliability, since cloud services have been developed to serve a large number of users and are in most cases very stable. There is another advantage regarding the usability of the applications which incorporate services from the cloud: most users already know how to interact with them since they have already used them in other contexts.

In this work, we propose an architecture and present a framework based on it to design and implement learning activities which harness the opportunities offered by the cloud. For this, we start from the requirements of the Situated Learning theory and explore the role of Cloud Services in supporting new forms of technology-enhanced learning activities fulfilling these requirements. This work considers the features of the common understanding of Cloud Computing, transferring the abstracted features to other prominent internet services like, e.g., Twitter and Facebook (which we see as specific instances of Cloud Services in the context of this paper). We argue that in the context of learning scenarios a wider definition of Cloud Services is need to encompass possibly relevant new developments. Furthermore, this paper presents an architecture that allows the flexible usage of services that belong to this extended definition of Cloud Services. We describe two examples of learning scenarios that build upon the presented architecture to demonstrate how these services facilitate innovative aspects of technology-enhanced learning scenarios. Then, we present a framework developed in order to ease the development of applications taking advantage from Cloud Services and we describe how to use it. Finally, an outlook for future development of this understanding of Cloud Services is presented.

2. Related work

In this section we will review the relevant literature for this work. Firstly we will present relevant work on using Cloud Computing in general, and what we defined as Cloud for educational purposes, as described in the previous section. Secondly, we review the literature about computer applications implementing geo-collaboration supporting learning activities that fall under the Situated Learning theory umbrella. Thirdly we will review the literature about microblogging used to support discussions within learning activities, understanding that microblogging services as a kind of Cloud Services.

2.1. Cloud Computing for learning

The potential of Cloud Computing for improving efficiency, cost and convenience for the educational sector is being recognized by a number US educational establishments [7], e.g.: (1) The University of California (UC) at Berkeley, found cloud computing to be attractive to use in one of their courses which focused exclusively on developing and deploying SaaS applications. Using Amazon Web Services, UC Berkeley was able to move its course from locally owned infrastructure to the cloud. One of the main reasons was quoted as being the ability to acquire a huge amount of servers (needed for this course) in a matter of a few minutes [8]; (2) researchers at the Medical College of Wisconsin Biotechnology and Bioengineering Center in Milwaukee are making protein research more accessible to scientists worldwide, thanks largely to renting processing time on Google's cloud-based servers. With cloud computing making the analysis less expensive and more accessible, it meant that many more users can set up and customize their own systems and researchers can analyze their data in greater depth than was previously attainable [9]; (3) faced with budget cuts the Washington State University's School of Electrical Engineering and Computer Science (EECS) selected a cloud platform (namely vSphere 4) from VMware (a leading provider of virtualization technology) to support a move to cloud computing. The EECS claims cloud computing has actually enabled it to expand the services it offers to faculty and students rather than cut them back [10].

Cloud computing is also finding its way in British academia, a number of UK higher education institutions, e.g., Leeds Metropolitan University, the University of Glamorgan, the University of Aberdeen, the University of Westminster, the London University's School of Oriental and African Studies (SOAS) and the Royal College of Art (RCA) have adopted Google Apps. Popular demand from students (many of whom were already abandoning the unreliable in-house email systems) and cost were said to be the main factors behind this move [11].

According to Alabbadi [11], Cloud Computing is being widely deployed, with its dynamic scalability and usage of virtualized resources, in many organizations for several applications. It is envisioned that, in the near future, cloud computing will have a significant impact on the educational and learning environment, enabling their own users (i.e., learners, instructors, and administrators) to perform their tasks effectively with less cost by utilizing the available cloud-based applications offered by the Cloud Service providers. Alabbadi [11] analyzed the use of cloud computing in the educational and learning arena, to be called Education and Learning as a Service'' (ELaaS), emphasizing its possible benefits, and offerings. This research indicates that it is essential for an educational and learning organization, with its budget restrictions and sustainability challenges, to use the cloud formation best suited for a particular IT activity.

de la Varga proposes a classification of already existing and popular Cloud Services many providers offer for free, according to their possible usage in education [12]. According to this classification, in the category of collaboration we have GoogleDrive, Dropbox, Slideshare among others. In the category of communication we have skype and Blogger. Twitter and Moodle fall in the category of interaction, while Gimp and Campstudio in the category of creation.

Cloud Computing has already made its way into the learning scenario, mostly by providing services and infrastructure. It is then natural to go one step further and see the cloud as providers for various services and data which can be integrated in a new application supporting learning activities.

2.2. Geo-collaboration and situated learning activities

Geo-collaboration is a complex computer-supported collaborative working situation where people execute diverse tasks geo-referencing data and information using mobile devices or desktop computer [13]. These tasks may involve collaborative exploration or mapping meaningful representations and/or interpreting geographically related data, making geospatial decisions collaboratively in various situations, like crisis management [14], collaboratively planning [15], or collaboratively defining strategies [13]. A central issue in geo-collaboration is the modeling of collaborative tasks performed by a group of people involving the contextualization, construction and exchange of geo-referenced data and information using a human–computer interface that shows the map of the physical zone where the tasks are being performed and/or spatially contextualized.

By conducting collaborative educational activities by geo-referencing information in authentic contexts and physical locations students can establish significant cognitive relationships between what was understood inside the classroom and what is visualized in a real context [5,6,16]. These educational practices are based on the Situated Learning theory. According to Antunes et al. [17,18] it is possible to introduce an added value to Situated Learning applications by geo-referencing data and information such as texts, images, files, sketches, etc., at concrete physical locations where instantiating the objectives of learning is required, [18], and by collaboratively exploring and reporting what is happening in their environment [6]. Collaborative activities can be introduced in Situated Learning scenarios by letting participants collaboratively geo-reference information, as well as solving tasks in particular locations taking advantages of the affordances of mobile technologies. Students may work at the same time and in the same place, at the same time and in different places, at different times in the same place or at different times in different places. According to Herrington and Olivier [19], there are nine elements that characterize Situated Learning applications: E1. Authentic context. E2. Authentic activities. E3. Access to expert performances and the modeling of processes. E4. Multiple roles and perspectives. E5. Collaborative construction of knowledge. E6. Reflection to enable abstractions to be formed. E7. Articulation to enable tacit knowledge to be made explicit. E8. Coaching and scaffolding. And E9. Authentic assessment.

We analyzed six research works [6,20–23,5]. They were chosen because they have many of the elements literature says is characteristic of situated learning applications as well as using geo-referencing data and information on Google Maps or Google Earth. Table 1 shows the characteristics of these research works and how they comply the elements of Situated Learning (with labels E1–E9) explained before.

From the analysis of these works, we can derive the following: (a) All works were conducted with primary and secondary students, between 10 and 17 years old; (b) learning activities were associated to specific objectives: learning a foreign language [24], learning natural sciences [6,20], and recognition of historic sites [5,21]; (c) all works provide results about usability and technical performance of the applications proposed, but do not mention any outcomes about the achievement of educational objectives except for [20]; (d) all the studies selected use GPS (embedded or as an external accessory) to locate student's activities geographically; (e) all works allow geo-referencing data objects over maps and support collaborative work among students; (f) maps are provided by Google Maps [5,21,23], or Google Earth [6,22].

From the requirements stated by Herrington and Oliver, the less frequently considered were: access to expert performances and the modeling of processes (E3), coaching and scaffolding by the teacher at critical times (E8), and authentic assessment of learning within the tasks (E9).

Finally, it is important to highlight those aspects related to the use of cloud computing in the development of the applications and their portability. Although most works do describe with some detail the software architecture of the developed application and technical characteristics referring to the use of a central server, communication protocols, and implementation language, none of them refer to the use of Google Maps or Google Earth as Cloud Services, nor they recognize in this practice a model for developing future applications taking advantage of Cloud Computing. Regarding portability, all applications have been developed for a certain particular platform. On the other hand, none of the applications defines the maximum number of users that can use them; all reported numbers which do not exceed the couple of dozens, 25 being the highest. While this does not mean that such applications cannot be used by more users, it is clear that they were not designed for a large number (hundreds or thousands) of users like those which cloud computing services can cope with. This also means, the developed applications are not intended to have widespread use. Regarding their accessibility, all them require to be run in specific computational devices. This contrasts with the spirit of cloud computing proposed in this article, where applications can be executed from any device which has an Internet connection and a browser, which introduces an important characteristic of flexibility and accessibility, being independent of the operative systems and type of the computational device.

Computer supported collaborative systems can benefit from using services provided by cloud computing since they offer a common infrastructure enabling access to an extended pool of resources that can provide supercomputing capabilities as well as specific hardware resources [25]. Moreover, combining the use of cloud services along with standard web protocols and developing languages like HTTP and HTML5 with JavaScript the systems can be used by almost any mobile or non-mobile computer device.

2.3. Microblogs as a communication support for learning activities

A microblog is a popular service in social networks where users can post and share information, by writing short messages using mobile or desktop computers [28]. Since most microblog sites are available through the internet and offer various interfaces for desktop PCs, tablet PCs and Smartphones we consider them as Cloud Services.

Researchers report that Twitter is used to communicate with others, give and receive information on current news, and to discuss activities to others [29]. They recognize three categories of users: producers of information (a minority), friends, and information seekers. Microblogs have made their way in educational contexts as they can be accessed anytime, anywhere [30,31]. Recent research has identified benefits and drawbacks associated with the use of microblogging.

Benefits are: (a) the use of microblogs meets the necessary requirements to be introduced in educational contexts: accessibility, immediacy, interactivity, and situating learning activities [28]; (b) students get feedback on their comments [32], feeling motivated to keep virtual and face-to-face discussions with their classmates, get valuable information, keep informed on what happens in their courses in an entertaining way [33], and develop competencies to transmit relevant and summarized information, [33]; (c) it has a positive influence in the process of argumentation and discussion [33], favors students reflection processes [32], supports collaboration [34], creativity [35], critical thinking, development of communication skills [34]; (d) encourages the construction of communities of practice [34,36] allowing the acquisition of social/cultural skills; (e) motivates students to feel more comfortable to raise and answer questions they would not dare in class [37,38];

Table 1
Characterization of recent research on situated learning applications and elements of situated learning.

	[20]	[5]	[26]	[16]	[27]	[6]
Part 1. Summary characterization of recent research on situated learning applications						
Learning objective	Enriching the field experience	Promote physical activity and collaborative problem solving	Learning game through participation problem solving	Learn Japanese polite expressions	General application where the pupils use maps to share the knowledge	Creation of content in the hands of children by environmental information: temperature and humidity
Name	Not provided	Skattjakt (treasure hunt)	Not provided	JAPELA'S	Sketch map	Usense2learn platform
Educational level	Students between 10–12 years old	Students between 12–15 years old	Not described	Japanese high school students	Sixth graders students	25 children (13 boys and 12 girls), aged 10 to 11, from a classroom of an elementary school
Technology	Nokia 6630, GPRS connection, GPS HP iPAQ 6515	Nokia 6630 with GPRS connection	Laptops with GPS receiver and Google maps	Pocket PC 2002, RFID tags and GPS	Tablet PC, a USB camera and GPS receiver	Mobile phone, laptops based on the Intel Classmate PC, sensor for air temperature and humidity measurement.
Learning activities	Exploring trees and their environment and the history of city square	Exploring informal skills and learning about local history	Treasure hunt game to identify any historical place, museum, or location	Go to the streets and use the PDA to have a conversation with correct Japanese expressions	Create a map in the neighborhood of their school with photos, sketches, sounds and videos	Observe and comment the temperature and humidity data acquired at several points
Collaboration mode time and space	Same time, same place among students, different place and different time with teacher	Same time, same place among users	Same time, same place and different places among users	Interaction with experts, teachers or peers in synchronous or asynchronous communication	Same time, same place and different time and places among users and teacher	Same time, same place among student, different place and different time with teacher
Geo-referentiation or localization	The teacher assigns areas where students must go	The students have to read and interpret maps and go to required places	Players identify the location of treasures and can see its location and the location of other players in Google map	The teacher and other students can locate the student wherever he is	The students create maps with geo-referentiated objects located in their real positions	The students geo-reference temperature and humidity data in their schoolyard
Part 2. Elements of situated learning according to [19]						
E1	X	X	X	X	X	X
E2	X	X	X	X	X	X
E3				X		
E4					X	
E5	X	X	X	X	X	X
E6	X			X	X	X
E7	X	X	X		X	
E8	X			X		
E9						X

(f) teachers rely on a space for discussion outside the class [37], increasing its dynamics [38], offering direct and immediate feedback to students [32,38], and favoring the inclusion of students in the real world [33].

Disadvantages are: (a) students' distraction due to the information volume that is not relevant in the educational process, [33]; (b) lack of courtesy in communications, [33]; (c) grammatical errors as there are 140 characters per entry; (d) teacher not being available to provide feedback to students through the microblog [33].

Furthermore, we analyze seven recent studies [32,36,37,39,40], which present nine concrete applications of microblogging in the educational context. The criterion of selection was to consider those applications using Twitter inside as well as outside the classroom, getting closer to the Situated Learning paradigm. The outcomes of these analyses are: (a) all of them are focused on university students; (b) 6 applications [32,35,36,39] (Ref. [39] describes three applications) show a positive increase in the communication and social interactions of the students, additionally one of them [35] reports positive outcomes in self-learning, creativity and innovation; (d) consideration of authentic contexts for learning were addressed in only three studies [36,38,40], particularly for learning a foreign language in a real context of communication, without intensive mobility and interaction in and outside the classroom; and despite that four applications [36,38–40] used mobile devices, none of them take advantage of the characteristics of mobility and portability in order to promote learning in real contexts placed in concrete physical spaces outside of the classroom.

Bollen et al. [44] present an example consisting on the implementation of an asynchronous discussion board for learning purposes, in which learners can contribute with text inputted in various ways like, Twitter, Facebook, email or even SMS messages from the mobile phone. This is an interesting approach from the point of view of this work since it combines different services for implementing the input of data for a new application.

According to the revised literature, we conclude that Twitter can be used as an effective mechanism to support communication by situated learning applications users, as proposed in this article, mainly because: (a) its simplicity and widespread use, (b) support

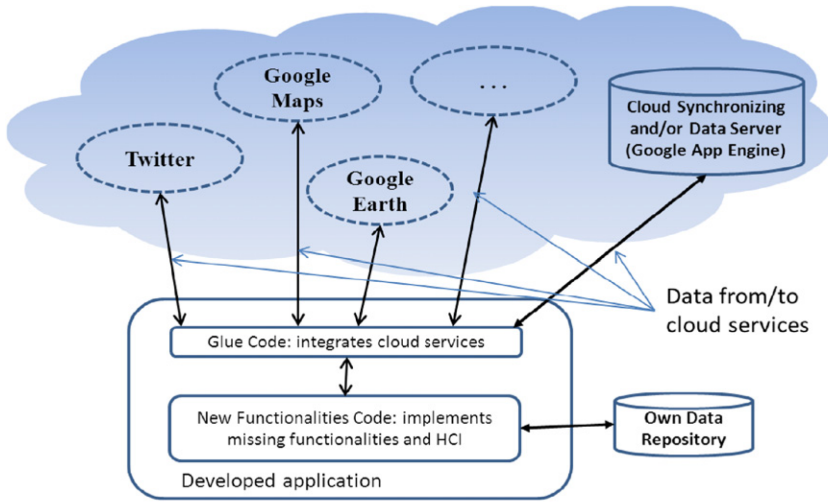

Fig. 1. The picture shows the logical general schema of the proposed architecture. Twitter, Google Earth and Google Maps are an example of the Cloud Services that may be used. Google App Engine is shown as an example of a Cloud Service which may be used as an external repository or for synchronization.

for the self-learning and creativity, (c) positive results in learning environments (argumentation, discussion, reflection, etc.), (d) its ability to be used both synchronously and asynchronously. On the other hand, none of the situated learning applications discussed in Section 2.2 presents a communication mechanism based on Twitter, or other cloud computing services. We believe its integration into applications like the one proposed in this work is a novel and useful approach.

3. An architecture model for using the cloud

Service Oriented Architecture (SOA) and Cloud services go hand in hand. Well defined, standardized protocols provided by SOA allow developers use services provided by the cloud in order to develop new applications by using various services from different providers and combining them to develop a new application using a "glue-code" [41]. In fact, the geospatial community has adopted this paradigm as a standard for building information infrastructures [42].

A starting point for our proposal is the SOA approach for developing software and the work presented by [43], in which the approach presented by [44] is abstracted and presented as an architecture which takes advantage of the already existing "cloud services" for collecting inputs, this way, achieving improved "accessibility" to the new system in the sense that this can be accessed through various means.

Our approach goes one step further by proposing that various services provided by the cloud could be used not only for implementing data input in a convenient way but also for other functionalities the new development may require. In the particular case of systems for implementing Situated Learning activities based on geo-collaboration we see at least the following functionalities which can be integrated using services available in the cloud:

- Maps: Maps are the basis of most geo-collaborative applications. Maps are in fact the principal collaborative workspace over which participants create artifacts and communicate their findings and/or proposals synchronizing their work. Today we have various sources where we can get those maps for the whole world like Google Maps and OpenLayer for 2D maps, Google Earth for 3D maps. They offer very useful APIs in order to download and manipulate maps inside stand alone or web-based applications.
- Authentication: Although security might not be of paramount importance for learning scenarios, the identification of a user in order to provide awareness to the rest of the group (other students and teacher) is a key functionality. It is indeed important for many learning activities to identify which student has generated a certain learning material or has performed a certain activity. Google's Authenticator service (called OAuth) may be used to incorporate this functionality in a new application. Facebook may also serve for this purposes if students already have an account.
- Discussion board: Communication is a key characteristic of Situated Learning and also a must in geo-collaboration activities. In order to collaboratively construct knowledge artifacts based on maps, learners need to exchange, evaluate and rank the ideas they propose to the rest of the group. In Section 2.3 we presented the benefits of microblogging as a way to implement discussion and communication in learning settings. As presented in [43,44], social networks like Twitter or Facebook, as well as other Cloud Services, may be used to implement the input to these kind of functionalities.
- Synchronization: real time synchronization of data is sometimes necessary, especially while working collaboratively on the field [53]. Implementing this functionality from the scratch may require a lot of work. Cloud Services like Google App engine, Microsoft Window Azure or Amazon's Elastic Compute Cloud could be useful platforms to be considered for implementing this part of the system.
- Data storage: Although synchronization services may also be used to implement data storage, sometimes it is simpler to integrate a data storage from the cloud. For this, there are many possibilities which offer APIs to store data in varied formats: Amazon S3 API for Online storage, Apple iCloud API for Cloud storage service, Dropbox API for files, Google Storage API, KIT Video API among many others.

Fig. 1 shows alogical schema of the general architecture we propose for developing geo-collaborative application supporting learning activities based on the Situated Learning theory, and taking advantage of the existing Cloud Services for implementing key functionalities of the application. The new application which is being developed has a "glue-code" component which is the part of the code implementing the conversation with the Cloud Services being used through their APIs sending and receiving data and/or invoking functions. This part also interacts with the code that has been developed in order to implement additional functionalities which are not provided by the cloud services, including the interface and the human–computer interaction. This part of the code may also in some cases implement functionalities for data storage in an own server or repository. This might be necessary in the case that available Cloud Services may not match the requirements needed, for example, because the data to storage may be sensitive and some institution may require that students' data should be stored in facilities belonging to the organization.

Typically, there are three different ways for using web based services from the cloud: (a) Preconfigured JavaScript/HTML code ready to include, (b) URL relative components and (c) Rest API. Preconfigured code can be a Twitter widget (e.g. Hashtag latest tweets box), these components are easy to integrate, however this leaves no option to interact or read their content. URL relative components are a little bit more flexible. These kinds of components change their behavior according to the loaded URL, for example, a Facebook comments box. Rest API's are very popular and most of the web applications with integrations options use a Rest API with JSON data format. Rest has the same advantage as WebServices, however, it is simpler to use and has a URL format for queries, i.e. https://graph.facebook.com/me returns a piece of data with the user's Facebook profile information using JSON data format.

In order to boost portability of the developed applications, our approach proposes to develop the applications using HTML5 and JavaScript, which seems to be on the way to establish themselves as standards for browsers running on the most varied and incompatible platforms: Desktop PCs running Windows, Tablets and Smartphones running Android and iPads running iOS. With its new features HTML5 is capable of implementing rich interactive applications running on a browser [54].

Of course, the schema presents a superset of all features that can be present in a system developed with the proposed approach. Particular developments may have only some of all features presented here.

4. Two situated learning applications supported by cloud services

In this section we will describe two example applications developed under the principles of Situated Learning using geo-collaboration which make use of Cloud Services following the described architecture.

4.1. Geo-collaborative application for "Learning with patterns"

Patterns play a significant role in learning. Research findings in the field of learning psychology provide some indications that human learning can be explained by the fact that learner discover, register and later apply patterns [45]. These cognitive processes "involve actively creating linkages among concepts, skill elements, people, and experiences". For the individual learner, the learning process involves "'making meaning' by establishing and re-working patterns, relationships, and connections" [45]. Patterns are recurring models, often they are presented as solutions for recurring problems. Natural sciences, mathematics and arts also work with patterns. The exact use of the term however, varies from discipline to discipline. The first formalization of pattern description and their compilation into networks of "pattern languages" was proposed by Alexander et al., [46]. A pattern consists of a set of components including the name of the pattern, description of the problem it solves, the solution to this problem, an example and the relations it has to other patterns. This approach has been adopted by many disciplines like architecture, software development, interaction design, pedagogy, etc. Although the evidence that patterns play an important role in learning they have seldom been used to support the development of cognitive and social skills apart from the field mathematics.

The notion of "seamless learning" [47] has been proposed to define these new learning situations that are marked by a continuity of learning experiences across different learning contexts. Students, individually or in groups, carry out learning activities whenever they want in a variety of situations and that they switch from one scenario to another easily and quickly. In these learning situations, learners are able to examine the physical world by capturing sensor and geo-positional data and conducting scientific inquiries and analyses in new ways that incorporate many of the important characteristics suggested by situated learning. Following this learning paradigm, we have developed a prototype of a system to support geo-collaborative learning activities that include collecting data on the field in order to find evidence of previously known patterns, for example, knowing the patterns of neo-classical architecture found in the city, or discovering patterns starting from the evidence found on the field (e.g., studying the reasons of why certain patterns of trees appear more often in city parks). According to the specific scenario described in the next paragraphs, the following functionalities for a system supporting them have been identified:

Creating patterns: To create a pattern means to define its components, describing its elements: name, description, context, etc. For each pattern, these components are annotated over the map by free-hand writing (see Fig. 2). Additional multimedia objects (pictures, videos, etc.) can be associated to the description of the pattern. The teacher can create these patterns and tasks during the class, as they are presented to the students before using an electronic board or projecting the screen of a touch sensitive computer to the whole class.

Creating tasks: Teachers create tasks, consisting of instructions about activities students should perform. They may include the description of activities and their correspondent instructions annotated over the map with a specific path (left of Fig. 3), or to randomly explore a pre-defined area within the city in order to find evidence of patterns (right Fig. 3), or visiting specifically marked places (right of Fig. 3). Therefore, the teacher can define a path, an area, or mark points by freehand sketching the limits of it onto the map. Consequently, the task for the students will consist of exploring a geographic area by following a path, randomly visiting a concrete area, or specifically visiting marked locations, in order to collect data about the instances of a pattern. Furthermore, the teacher can associate previously defined patterns to the task or create new ones inside the task creation process. Fig. 3 shows the creation of various tasks and their associations of these to the corresponding pattern(s).

Assigning tasks to students: In the classroom, before performing the field activity, students start the application on their mobile devices. The teacher's application automatically discovers the students' application and displays them on the screen as an icon. By just dragging and dropping the student's icon over the task icon, the task proposition is transmitted to the student's device and shown.

Instantiating patterns: According to the proposed task, students may follow a certain path, explore an area of the city, or go to specific places gathering data to collaboratively create instantiations of the pattern when they find a certain elements that they think correspond to the pattern giving by the teacher. Instantiations consist of text descriptions, pictures or sketches of a certain object found which complies with the pattern definition (see Fig. 4).

Monitoring students' work: teachers can monitor the students' work in areas where Internet is available and a client–server communication is possible. The student's application sends the current

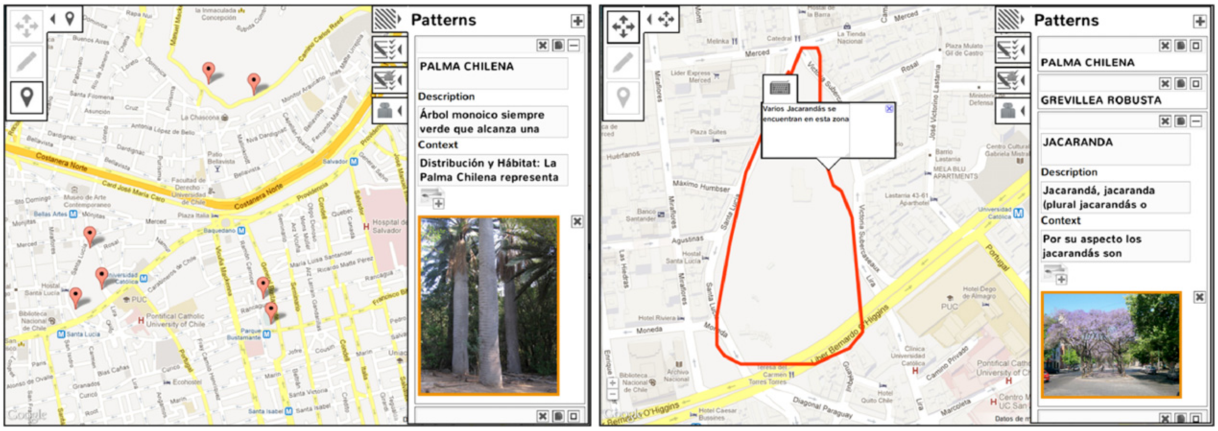

Fig. 2. Teacher's view of the system. Left: pattern creation of a "Palma Chilena" with a picture of it, that is geolocalized in the exact locations where they are found. Right: pattern creation of a "Jacaranda", whose picture illustrates an example, and also the region where they are found, which is indicated on the map.

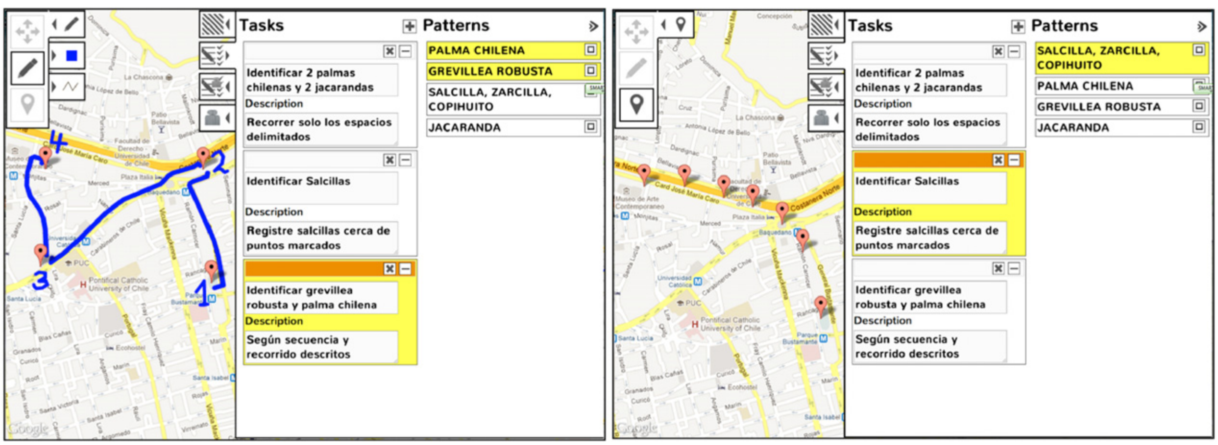

Fig. 3. Teacher's view of the system for the task definitions, which are made by following a path (left), and marking specific locations (right) in which the students need to work with.

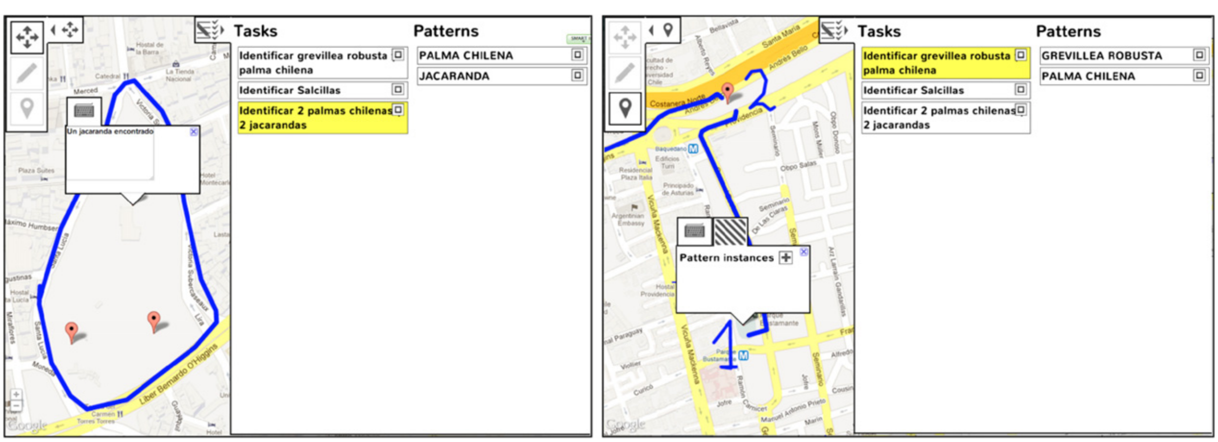

Fig. 4. Two students' views, with instances of the patterns and tasks provided by their teacher. Each of the three tasks shown in both interfaces, belong to the same team. The third assigned task is highlighted on the left and the right shows the first. Both interfaces show the task development already done collaboratively.

position at regular time intervals to a server. This information is taken by the teacher's application, which displays the student's position on the map. It is also possible for the teacher to communicate with the students via chat to give more instructions about the task in "real time".

Fig. 5 shows the architecture of this application. It uses Google Maps as the maps provider and Google Authenticator for managing students' accounts. It also uses Google App Engine for synchronizing the students' work among them when working on the field. Additional code was developed to define patterns, tasks, assign task to students. It was also necessary to develop code in order to implement the handwriting over the maps. A local server was used in order to store the data from the patterns and the students' work. The client side applications, including the

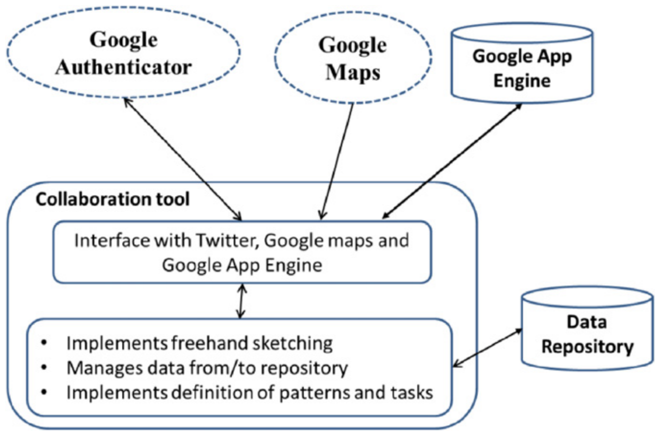

Fig. 5. The figure shows the logical architecture of the "Learning with patterns" application. It uses three services for the cloud; Google Authenticator for managing students' identity, Google Maps and Google App Engine for synchronization of the students' work on the field. Additionally, it implements a Data repository for storing the definition of patterns and tasks and the students' work.

teacher's and students' interface were programmed in HTML5 with JavaScript. The PhoneGap library was used in order to get access to the GPS and digital camera of the mobile device. The Data repository functionality was developed using Java Servlets.

4.2. Geo-collaborative application for "Learning with simulations"

Teaching and learning wireless communication is a challenging issue mainly because it is difficult for students to translate the theoretical models that are commonly used to explain the propagation of the signal into explicit, practical knowledge [48]. This learning situation provides a suitable scenario to introduce situated learning principles in a computer supported learning activity carrying out authentic activities [18,21].

In wireless network planning, engineers must determine the location of a set of transmitters in order to cover the area using the minimum of resources [49]. For this, they use computational models that simulate the propagation under various landscape conditions (urban areas, sub-urban areas, mountainous areas, flat countryside areas, etc.) [50,51]. Choosing the right model for each situation is not an easy task because some scenarios may combine various landscape types at the same time. Therefore, planning the network requires performing real measurements at various locations in order to check if the applied model predicted the propagation correctly. Otherwise it will be necessary to correct the assumptions. It is important that engineering students understand the difficulty in choosing the right model and that the chosen model may not apply for the whole area which they are considering for simulating the signal propagation.

Starting from the above mentioned activity taken from the real-life, a learning activity was designed based on the Situated Learning theory. For this, we defined two roles: *planner* and *measurer*. For each role a specialized tool was developed in order to support their activities [52].

The learning activity envisages three stages: the first one is the theoretical session where students learn in a classroom setting the various existing models for simulating the signal propagation. They also perform several simulations with these models exploring which is the coverage of the signal for various existing antennas according to the models—different models will give different coverage zones as result. Students get the necessary information about the antennas in order to perform the simulation, (geographical location, height, strength, radiation pattern, etc.). Students choose the propagation model they consider is the most adequate given the characteristics of the area, like geomorphology and construction density. The second stage starts after the simulation is performed and simulated data about the signal strength for the whole area is obtained. Then, students receive a set of coordinates of various geographical points, which they have to input into the collaboration tool along with the data about the simulated signal strength for each of these points. While performing this stage the measurers have to go to the same places designated by the coordinates, which were given to the planners. At those places, measurers use professional signal strength tools to obtain the corresponding information of the real signal strength at that location. Then, they input this data using the collaboration tool in order to share it with the rest of the team.

During the third stage, planners and measurers work using a collaboration platform in order to identify the model that better predicts the real value of the signal strength. However, students will realize that there is no single model which predicts the real value for the whole area. The actual learning occurs when students have to justify the reason for this, by checking the geography of the site where the signal strength was measured and the surrounding buildings. The system allows them to input and browse the simulated and real data in order to compare them and start discussion. Fig. 6 shows the learning activity schema.

The developed software consists of two applications, one for each role. These are the *coverage analysis tool* for planners and the *collaboration tool* which is used in both steps by both roles. The coverage analysis tool allows students to perform simulations and store the results. The collaboration tool allows students to enhance the learning experience by including the collaborative learning activities in the way the Situated Learning theory recommends.

The coverage analysis tool has two interfaces, one for desktop computers and another for mobile devices. The desktop interface (see Fig. 7) supports the planning activity in the classroom which includes performing simulations and storing the generated data. The mobile interface (see Fig. 7) is designed to provide the simulation data while working on the field.

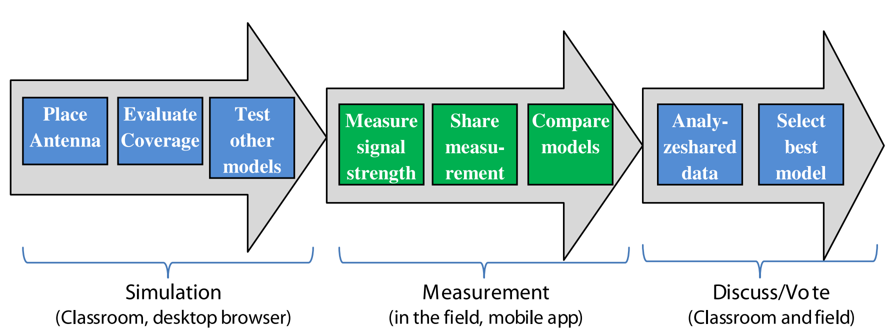

Fig. 6. Schema of the learning activity.

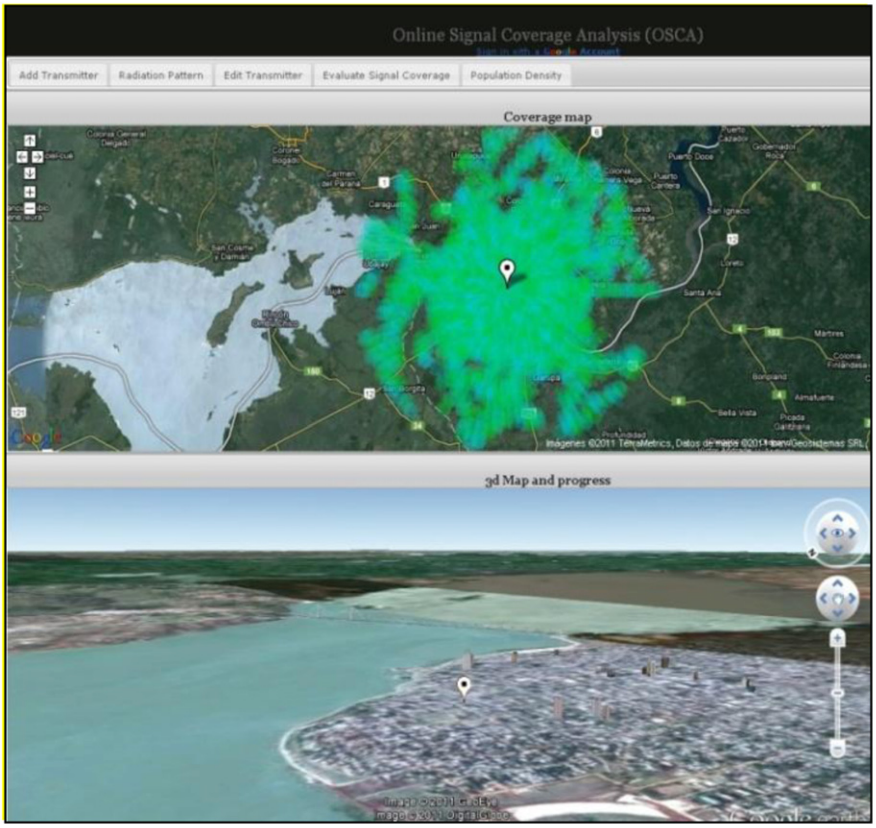

Fig. 7. Coverage analysis tool for desktop devices with the 2D (top) and 3D (bottom) views. The white mark on both views represents the location of the antenna. The light green area of the 2D view corresponds to the area covered with signal according to the simulation model. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The Desktop interface has four main features:

Add transmitter: The goal of this feature is to provide an easy way to perform the planning step, using a 2 and a 3 dimensional map. The 2D map is used to specify an approximate location of the antenna. This map synchronized with the 3D view (see Fig. 7). The 3D map is necessary because the propagation of the signal highly depends on the geomorphology where the antenna is located. After this, the antenna can be set with a double click on the 3D view. Then, the technical specifications of the transmitter can be filled in a pop-up form (not shown in Fig. 7), which include the propagation model to be used in the simulation.

Edit a transmitter: In order to allow students to test different models, the specifications of a transmitter can be edited.

Radiation pattern: Each type of transmitter has a specific radiation pattern, which defines the transmission power on a specific direction. This is an important parameter for simulating the signal strength.

Evaluate the spatial coverage: This function performs the actual simulation by computing the signal strength in the whole area by applying the selected propagation model for that antenna.

The Mobile interface (Fig. 8) allows students to retrieve the simulated signal strength values at the current location according to all available models while students are working on the field. First, the Select antenna function should be performed in order to choose the antenna from the available set according to which the signal strength should be computed. Then the GetPosition button should be pressed in order to let the system retrieve the current position of the student with the mobile device using the GPS of the mobile device. The system then shows the simulated signal strength emitted from the selected antenna at the device's position according to all available models. At the right-hand side

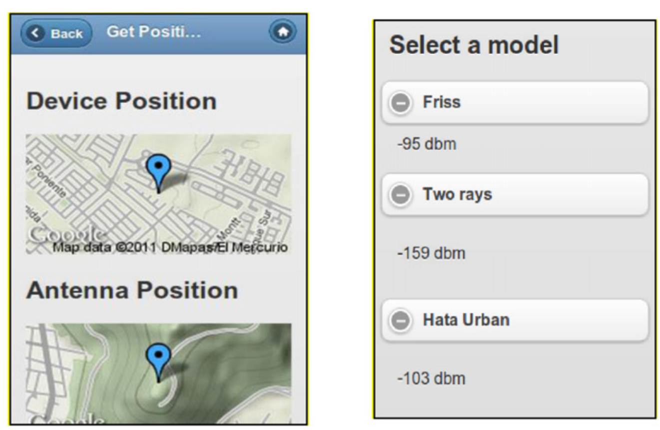

Fig. 8. The picture on the left shows the upper half of the mobile device's interface for the coverage analysis tool. The map on the top shows the student's current position according to the device's GPS. The map on the bottom shows the antenna's location. On right, the bottom half of the interface shows the signal strength values according to each available model is displayed.

the simulated signal strength according to the available models is displayed. At the left hand side the mobile device's position (where the student is current standing) and the selected antenna position are shown.

The collaboration tool has also 2 interfaces, one for desktop and another for mobile devices. The desktop interface is used during the planning activity in the classroom and the mobile is the collaboration tool which is used on the field while students are measuring the signal strengths. The desktop version has 2 features: report a simulation value, and vote for a measurement

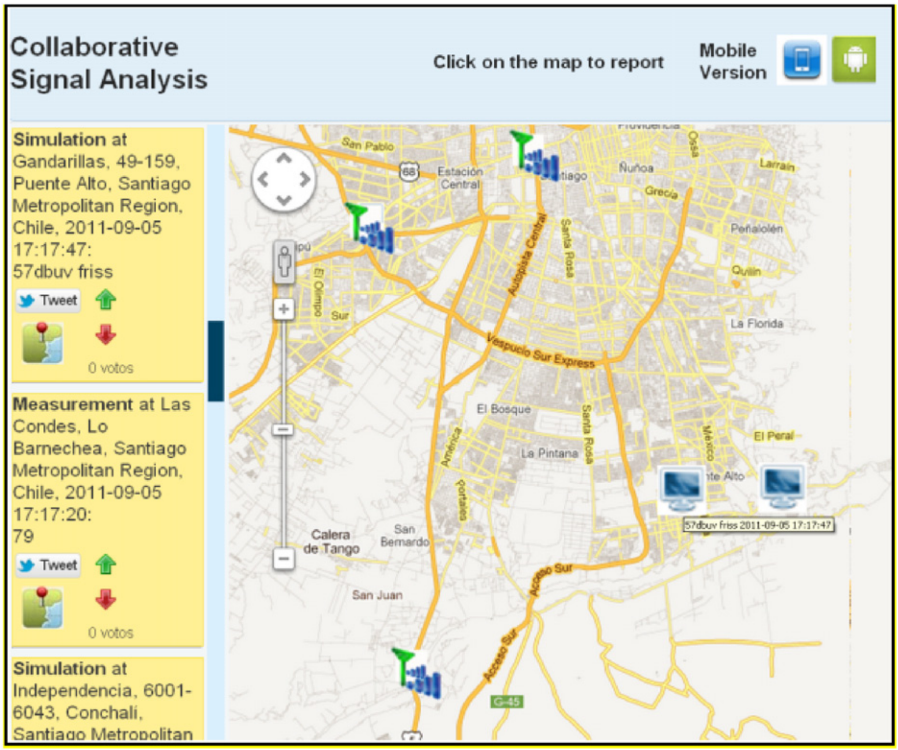

Fig. 9. The desktop web browser interface is used to input simulated or measured signal strength values for various locations. For this the user clicks on the map and enters the information. Icons showing a small screen indicate a simulated value for that location was inputted, icons showing an antenna indicate a measured value was registered for that location. On the left column, detailed information for each data on the map is shown, as well as button for discussion inputs which is made via Twitter.

or simulation. The mobile has 3 features: report a measurement, vote for a measurement, and vote for a simulation.

Report a simulation (available on desktop version only): Students publish the simulated signal strength for a certain location in order to have the values available for the evaluation step, in order to allow students to compare this value with the measured one (see Fig. 9).

Vote (available on desktop and Mobile versions): During the evaluation step students have to choose the most adequate model to predict each measured value of the signal's strength. While planners have better information about the simulation results and the geographical characteristics of the area between the antenna and the device position, measurers have on-site information about the local conditions for a certain point. Both actors can use the voting system to express their preference for one model or the other according to their information.

Report a measurement (on mobile version only): This functionality allows students on the field (measurers) to publish measured values to the rest of the group (other measurers and planners). The measurer first obtains the signal strength with a measuring device. In order to publish this value the button labeled with Signal should be pressed, then the value should be typed in and the Report button pressed. The system automatically adds the location information using the GPS feature of the mobile device and shows it on a map.

Fig. 10 shows the logical architecture for this application. The desktop version of the Coverage analysis tool uses Google Earth for representing the geomorphology of the area where the antenna is located in order to compute the propagation of the signal. Google Maps is used by the mobile version of the Coverage analysis tool in order to show the location where the student is currently located. The mobile version uses Google Maps instead of Google Earth because it requires less computing resources. The "glue code" of the Coverage Analysis tool was developed in order to

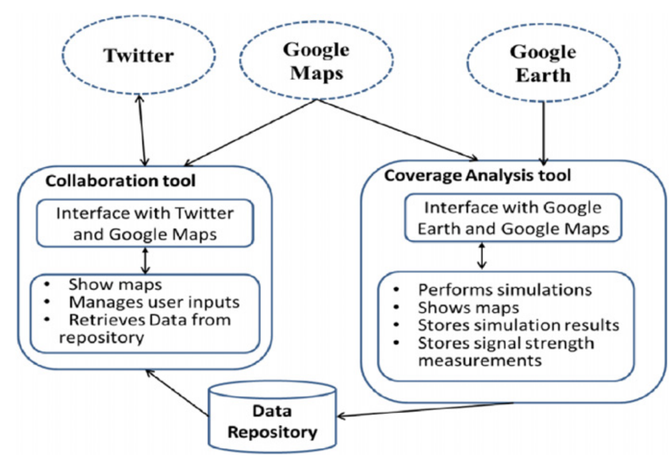

Fig. 10. The figure shows the logical architecture of the "Learning with Simulations" application. It uses three services for the cloud: Google Earth, Google Maps and Twitter. A data repository is implemented in order to store the results of the simulations and the measurements. This data is later used to discuss about the validity of propagation models in the area where the antennas are located.

implement the human–computer interaction which consists in accepting the parameters to perform the simulations of the signal propagation, graphically show the results, accepts the values for the measurements of the signal strength and storing this data on a repository which will be used later by the Collaboration tool.

The Collaboration tool uses Google Maps to show the locations and values of simulated and measured values of the signal strength and uses Twitter in order to implement the input for the discussion where students have to argue and vote for the validity of a certain model in a certain area. It takes the data stored previously by the Coverage analysis tool in the repository and displays it over the map.

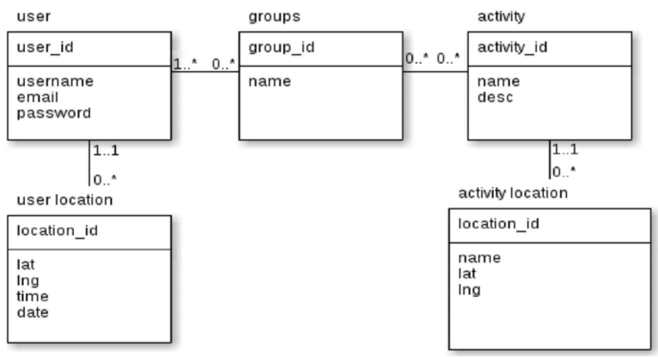

Fig. 11. The class diagram for the base data model, which should be extended to include data for the particular application being developed with the framework.

5. A framework to support application developers

The proposed architecture is meant for designing and developing applications supporting situated learning activities with geo-collaboration based on the MVC (Model-View-Controller) model. It uses automatic CRUD components (Create, Read, Update and Delete) and REST (REpresentational State Transfer) components as well as other components for the management of users and maps. The provided framework provides the following advantages:

(a) Faster application design process, since the application architecture is already provided and has been successfully tested.
(b) Security, robustness and scalability, since the provided components integrate with stable cloud services.
(c) Faster programming process, since the framework provides already developed components which automatically generate the necessary application interfaces.

The framework is extensible and adapts itself to different application scenarios giving that their data model is an extension of the one shown in Fig. 11. This means, the framework aims at supporting the development of applications where users, having a current location, are assigned to a certain group, and activities are assigned to the group. The activities should be performed at certain locations.

5.1. General description of the architecture

The framework was developed over the Codeigniter platform (http://ellislab.com/codeigniter) which is an open source framework for developing web applications with PHP, and follows the MVC model. One of its major advantages is the rapid learning curve. Fig. 12 shows the general structure of the framework.

At the top of the figure we see the cloud services with which the framework is able to communicate. Mapserver, Google Maps, and Bing Maps may be used to include maps in the developing application; Facebook, Google, OpenID and Twitter for user accounts. The framework also provides a convenient architecture and communication protocol in case the application has to interact with another mobile application (Mobile Apps). The framework integrates three components which were developed by third parties and are publicly available: The REST API and CRUD components manage the communication with mobile applications using HTTP REST protocol. A3M implements the communication with services providing management of User IDs functionalities. The Location component was developed especially for this work and manages the communication with several maps' providers. The developer may chose to use and interact with anyone available through Openlayers (http://openlayers.org/) which is an open source interface for managing map tiles and markers loaded from any source.

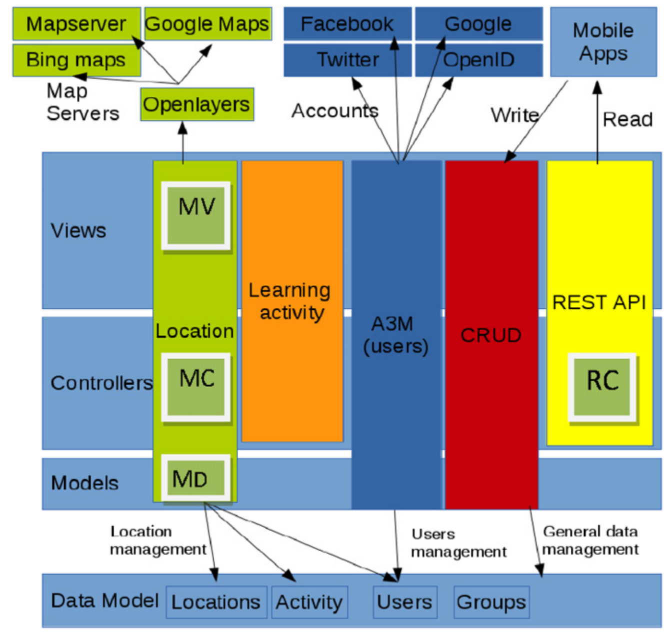

Fig. 12. The base data model of the framework.

The Learning activity component is the one that should be especially programmed each time because it implements the particular logic of the application being developed. The Location, A3M and CRUD components are responsible for managing the data of the application.

5.2. Components description

As we mentioned, A3M and CRUD are components developed by third parties which were included in this framework. A3M is a component allowing the automatic integration of user data taken from Facebook, Twitter, Google (accounts), Yahoo and OpenID, so the developer does not need to implement this functionality. A3M was developed by independent third parties and its stand-alone version is publicly available in Google Code (https://code.google.com/p/a3m/). CRUD is a component which allows the generation of interfaces for managing entities of a data model; in this case we have groups, activities, locations, users belonging to groups and activities taking place in locations as the basic data core. This component will also manage the whole data model including the additional data the developer may define to implement the new application. The component is freely available at (http://www.grocerycrud.com/). The A3M as well as the CRUD components are part of the model and the controller since both have a direct relationship with the logic and the data of the application.

The Location component was developed especially for this work and includes three sub components, one for each layer (Model, View, Controller). In the view layer we have the Maps Viewer subcomponent (MV) which uses cloud services to display maps. This component allows the developer to choose the maps provider and manages the display configuration in order to show the necessary maps,for example, the location related to users and activities. The views for managing the data model are self-generated on-demand by the CRUD component.

In the controller layer we have the maps' controllers (MC) which implement the control for maps showing the user location and maps showing the activity locations. This controller communicates with the A3M component in order to get the information of each registered user whose location has to be shown.

The REST controller (RC) was specially developed to facilitate the integration of the framework with mobile applications, which are an important application types and can make use of this framework. This controller interacts with the REST interfaces and allows the implementation of a wide range of queries to the data model. However, it is recommended to use it only for reading operations (i.e. to query and not to update data).

The component which has to be developed especially for each application is the Learning Activity component since it implements the application logic. For the proposed architecture, it is recommended to develop this logic in the controller layer. It will be certainly necessary to develop some application specific functionalities in the view layer to show data which is particular to the application being developed. It is also recommended to relay on the CRUD component to collect this specific data in order to avoid developing new code for functionalities already provided by this component.

All components of the framework described in this section are available for download in GitHub (https://github.com/jfrez/geo_framework), which is a version control system to be cloned and extended as required.

5.3. Implementation example

In this section we will describe how the Learning with Simulations application was developed using the framework previously presented. As already said, this application consists of two tools: the coverage analysis tool and the collaboration tool, the first one having a version for mobile devices and another for desktop computers.

In order to develop the coverage analysis tool first the data model of the framework was extended in order to include the "Antenna" class which describes the technical characteristics of an antenna (height, power, etc.). Then, using CRUD, we generated the necessary controllers and views to create, edit and delete antennas. In order to position antennas over the map the antenna creation interface was extended to allow users to position them over a Google Earth map. This modified view also includes the simulation models and the functionalities to paint the covered area over the map according to the simulation models.

For the collaboration tool, the data model was extended in order to include a class to store and manage the data resulting from measuring the signal strength while performing the activity on the field. CRUD automatically created the interfaces for adding, editing and deleting them. Additionally, a controller was created in order to show all antennas created during the simulation phase with the coverage analysis tool, as well as the measurements registered using the mobile application on the field. This controller is used by all views which generate and use a REST interface for Reading data. Using this controller, the mobile application can show the antennas, the stored simulation results, and the measurements with the interfaces generated by CRUD.

For the desktop version of the collaboration tool, a "learning activity" controller was developed which implements the logic of the activity. The views which are displayed by this controller use the same data reading interfaces used by the mobile application, thus desktop collaboration tools can also Access and show the results of the simulations and the measurements.

Since the developed applications are extensions of the framework they inherit functionalities for user, groups, activities and locations administration, thus it was not necessary to implement them.

6. Conclusions

Current developments in mobile computing and wireless networks facilitate and promote the implementation of computer supported learning systems that can be deployed ubiquitously. The Situated Learning theory can be used as a good frame for designing computer supported learning activities which take place on the field. An interesting subset of this kind of learning systems is the set of applications that make intensive use of geo-referenced information, when the knowledge being acquired is strong related to a geographical location. A key requirement for implementing these systems is the availability of maps and geographical information in general. Fortunately, nowadays this data and information is provided as Cloud Services by a number of providers for free.

In this work, we propose to go one step further by taking advantage of not only the geographical information but also other services which are provided as Cloud Services as well. Following this idea, we proposed an architecture which identifies the principal components of applications implementing activities based on the Situated Learning theory using geo-collaboration and make use of Cloud Services to implement them. Based on this architecture, we present two developments which make extensive use of services offered by "the cloud" and a framework for further developing other applications using a framework presented in Section 5. In this work we do not provide an empirical testing of the architecture and the framework, which would be very difficult to do. One way would be to measure the time required to develop a system with and without the platform, which should be performed by teams with similar capacities. Another way is to count how many program lines are spared because of the use of the platform. In Section 5 we describe in detail which functionalities the programmer does not need to develop anymore for one of the applications. This, we think, is a good way to show that the complexity of the development is reduced.

Although this approach may serve for developing a vast variety of applications, in this work we focus on validating it for the Situated Learning theory only. In Section 2.2 we presented the requirements for designing learning environments that support situated learning. Here, we will analyze how the two developed systems fulfill them. Table 2 illustrates how the developed applications comply with the requirements for situated learning, some in a better way than others. An important characteristic of the learning approach proposed in our current efforts is that it starts in the classroom, continues on the field; proceeds then at home or in a computer lab and ends with a learning session inside the classroom again. This again can create another cycle which is interesting from the point of view that these systems are able to support different learning modes and stages, without disruptions of methodology, interaction paradigm or data compatibility. In fact, the systems are able to run on different platforms. They have been used on PCs inside the classrooms, where the teacher used an electronic board as well as hand held and tablet computers. The common aspect on all these platforms is the touch screen and the big difference is the screen size. However, the way of using sketching and gestures to control the applications was positively evaluated by the early users. They also positively evaluated the fact that they use the same interaction paradigm regardless the platform they were using, so they do not need to learn how to interact with another application interface.

Below we provide some examples of different field in which we plan to conduct some future trials in order to validate our approach: (a) Geology students must perform collaborative activities like field measurements and observations that can be monitored and controlled remotely by a teacher. Students must geo-reference their notes, take pictures and make recordings at concrete points that will be constructed jointly and/or with their peers; (b) Architecture students may recognize construction styles and design patterns in specific areas of an urban space. Students may also collaboratively survey construction styles or

Table 2
The requirements and the system features fulfilling for both situated learning applications.

	Geo-collaborative application for "Learning with Patterns"	Geo-collaborative application for "Simulations"
E1	Patterns instances are searched for in the very place they appear naturally	The data of antennas as well as signal strengths are taken from a real context
E2	Finding pattern instances in natural environments is a typical work experts often do	Students have to measure real signals the way real professionals do
E3	There are two roles: the teacher and the student. In certain cases students might also propose tasks taking the role of the teacher	Students are advised by an expert (lecturer) and use professional modeling and measuring tools
E4	After completing the fieldwork, back in the classroom the teacher provides examples from the expert's regarding the task	Each task is performed assuming a different role in a different scenario
E5	Students work collaboratively on the field in order to collect the relevant data and share it	Students have to share and compare their analysis results in order to find the best prediction model
E6	Students present their findings in front of the class reflecting about the patterns they found	Students reflect on the results obtained in order to generalize the acquired knowledge
E7	The system allows students to collect data, relate and communicate them formalizing their unsorted ideas about what they found	The system allows students to collect data, relate and communicate them formalizing their unsorted ideas about what they find
E8	The teacher can help students during the work on the field, as well as back in the classroom	The teacher can help the students during the work on the field as well as back in the classroom
E9	Possible patterns and patterns instances are checked by the students and the teacher during the work	Assessment is provided by the system automatically as a feedback for decisions taken about antenna location and model election

design patterns in a certain zone using geo-referenced notes to understand the changes in the construction development; (c) Social sciences. Students of anthropology, psychology or sociology may conduct field observations for which collaboratively created data and information notes of diverse nature (text, images, video & sound), associated with its localization will enrich their observations.

Acknowledgments

This paper was partially funded by the "U-APOYA Program, VID 2011" of the Universidad de Chile, and Fondecyt 1085010.

References

[1] A. Drummond, Situated learning and assessment, in: Presented at the Teaching and Learning Symposium Wisconsunin, 2010.
[2] J. Lave, E. Wenger, Situated Learning: Legitimate Peripheral Participation, Cambridge University Press, 1991.
[3] L. Vygotsky, The development of academic concepts in school aged children, in: V.J. Valsiner (Ed.), The Vygotsky Reader, Blackwell, Oxford, 1994, pp. 335–370.
[4] N. Baloian, J.A. Pino, G. Peña, G. Zurita, Learning with patterns: an effective way to implement computer supported pervasive learning, in: 2010 14th International Conference on Computer Supported Cooperative Work in Design, CSCWD, 2010, pp. 677–682.
[5] D. Spikol, M. Milrad, Physical activities and playful learning using mobile game, in: Research and Practice in Technology Enhanced Learning, RPTEL, Vol. 3, 2008, pp. 275–295.
[6] M.J. Silva, J.C. Lopes, P.M. da Silva, M.J. Marcelino, Sensing the schoolyard: using senses and sensors to assess georeferenced environmental dimensions, in: Proceedings of the 1st International Conference and Exhibition on Computing for Geospatial Research & Application, New York, 2010, pp. 1–4.
[7] N. Sultan, Cloud computing for education: a new dawn? International Journal of Information Management 30 (2010) 109–116.
[8] A. Fox, Cloud computing in education, Berkeley iNews, ed. https://inews.berkeley.edu/articles/Spring2009/cloud-computing, 2009 (accessed 31.01.2013).
[9] E. La Susa, Cloud computing brings cost of protein research down to Earth, Eureka Alert! 2009 (accessed on: 31 January, 2013), ed.
[10] B. DeCoufle, The impact of cloud computing on schools, The Data Center Journal (2009) (accessed on: 31 January, 2013), ed.
[11] M.M. Alabbadi, Cloud computing for education and learning: education and learning as a service (ELaaS), in: 2011 14th International Conference on Interactive Collaborative Learning, ICL, 2011, pp. 589–594.
[12] A. de la Varga González, The importance of "cloud education" at development organizations, in: The 1st International Workshop on Cloud Education Environments, WCLOUD 2012, Antigua, Guatemala, 2012, pp. 1–6.
[13] A. MacEachren, G. Cai, R. Sharma, I. Rauschert, I. Brewer, L. Bolelli, et al., Enabling collaborative geoinformation access and decision making through a natural, mulimodal interface, International Journal of Geographical Information Science 19 (2005) 293–317.
[14] G. Folino, A. Forestiero, G. Papuzzo, G. Spezzano, A grid portal for solving geoscience problems using distributed knowledge discovery services, Future Generation Computer Systems 26 (2010) 87–96.
[15] G. Convertino, D. Zhao, C. Ganoe, J. Carroll, M. Rosson, A role-based multiple view approach to distributed geo-collaboration, Lecture Notes in Computer Science 4553 (2007) 561–570.
[16] C. Yin, H. Ogata, Y. Tabata, Y. Yano, Supporting the acquisition of Japanese polite expressions in context-aware ubiquitous learning, International Journal of Mobile Learning and Organisation 4 (2010).
[17] P. Antunes, G. Zurita, N. Baloian, A model for designing geocollaborative artifacts and applications, Groupware: Design, Implementation, and Use (2009) 278–294.
[18] G. Zurita, N. Baloian, Context, patterns and geo-collaboration to support situated learning, Ubiquitous Computing and Ambient Intelligence (2012) 503–511.
[19] J. Herrington, R. Oliver, An instructional design framework for authentic learning environments, Educational Technology Research and Development 48 (2000) 23–48.
[20] A. Kurti, D. Spikol, M. Milrad, Bridging outdoors and indoors educational activities in schools with the support of mobile and positioning technologies, International Journal of Mobile Learning and Organisation 2 (2008) 166–186.
[21] S. Bahadur, R. Braek, Platform support for situated collaborative learning, in: Presented at the International Conference on Mobile, Hybrid, and On-line Learning, 2009.
[22] S. Miura, P. Ravasio, M. Sugimoto, Situated learning with sketchMap, in: Presented at the Innovative Mobile Learning: Techniques and Technologies, 2009.
[23] B. Vogel, D. Spikol, A. Kurti, M. Milrad, Integrating mobile, web and sensory technologies to support inquiry-based science learning, in: 6th IEEE International Conference on Wireless, Mobile, and Ubiquitous Technologies in Education, 2010, pp. 65–72.
[24] D. Edge, E. Searle, K. Chiu, J. Zhao, J.A. Landay, MicroMandarin: mobile language learning in context, in: The ACM CHI Conference on Human Factors in Computing Systems, Vancouver, Canada, 2011.
[25] G. Vega-Gorgojo, M.L. Bote-Lorenzo, E. Gómez-Sánchez, Y.A. Dimitriadis, J.I. Asensio-Pérez, A semantic approach to discovering learning services in grid-based collaborative systems, Future Generation Computer Systems 22 (2006) 709–719.
[26] S. Bahadur, R. Braek, Platform support for situated collaborative learning, in: International Conference on Mobile, Hybrid, and On-line Learning, 2009, pp. 53–60.
[27] S. Miura, P. Ravasio, M. Sugimoto, Title, unpublished.
[28] C. Honeycutt, S.C. Herring, Beyond microblogging: conversation and collaboration via Twitter, in: Hawaii International Conference on System Sciences, 2009, pp. 1–10.
[29] A. Java, X. Song, T. Finin, B. Tseng, Why we twitter: understanding microblogging usage and communities, in: Presented at the Proceedings of the 9th WebKDD and 1st SNA-KDD Workshop on Web Mining and Social Network Analysis, San Jose, California, 2007.
[30] E. Kassens-Noor, Twitter as a teaching practice to enhance active and informal learning in higher education: the case of sustainable tweets, Active Learning in Higher Education 13 (2012) 9–21.
[31] S.B. Rinaldo, S. Tapp, D.A. Laverie, Learning by tweeting using twitter as a pedagogical tool, Journal of Marketing Education 33 (2011) 193–203.
[32] M. Ebner, C. Lienhardt, M. Rohs, I. Meyer, Microblogs in higher education-a chance to facilitate informal and process-oriented learning? Computers & Education 55 (2009) 92–100.
[33] G. Grosseck, C. Holotesku, Can we use twitter for educational activities? in: Paper to be Presented at the 4th International Scientific Conference eLSE eLearning and Software for Education, 2008.
[34] C. Holotescu, G. Grosseck, Learning to microblog and microblogging to learn, a case study on learning scenarios in a microblogging context, in: Conference Proceedings of eLearning and Software for Education, 2010, pp. 365–374.
[35] E. Carmona Altamirano, A. Nava Casarrubias, R.A. Mojica Benítez, Microblogging en la educación, Revista Digital Alternativa 6 (2009) 33–41.
[36] K. Stepanyan, K. Borau, C. Ullrich, A social network analysis perspective on student interaction within the twitter microblogging environment, in: 10th IEEE International Conference on Advanced Learning Technologies, 2010, pp. 70–72.

[37] R. Junco, G. Heibergert, E. Loken, The effect of twitter on college students engagement and grades, Journal of Computer Assisted Learning (2010).
[38] K. Borau, C. Ullrich, J. Feng, R. Shen, Microblogging for language learning: using twitter to train communicative and cultural competence, Advances in Web Based Learning—ICWL (2009) 78–87.
[39] T. Cochrane, R. Bateman, Smartphones give you wings: pedagogical affordances of mobile Web 2.0, Australasian Journal of Educational Technology 26 (2010) 1–14.
[40] C. Ullrich, K. Borau, H. Luo, X. Tan, L. Shen, R. Shen, Why web 2.0 is good for learning and for research: principles and prototypes, in: Proceeding of the 17th International Conference on World Wide Web, 2008, pp. 705–714.
[41] V. Vescoukis, N. Doulamis, S. Karagiorgou, A service oriented architecture for decision support systems in environmental crisis management, Future Generation Computer Systems 28 (2012) 593–604.
[42] L. Díaz, C. Granell, M. Gould, J. Huerta, Managing user-generated information in geospatial cyberinfrastructures, Future Generation Computer Systems 27 (2011) 304–314.
[43] M. Jansen, N. Baloian, L. Bollen, Cloud services for learning scenarios: widening the perspective, in: The 1st International Workshop on Cloud Education Environments, WCLOUD 2012, Antigua, Guatemala, 2012, pp. 33–37.
[44] L. Bollen, S. Eimler, M. Jansen, J. Engler, Enabling and evaluating mobile learning scenarios with multiple input channels, Collaboration and Technology (2012) 161–175.
[45] F. Restle, Theory of serial pattern learning: structural trees, Psychological Review 77 (1970) 481.
[46] C. Alexander, A Pattern Language: Towns, Buildings, Construction, Vol. 2, Oxford University Press, USA, 1977.
[47] L.H. Wong, C.K. Looi, What seams do we remove in mobile-assisted seamless learning? A critical review of the literature, Computers & Education 57 (2011) 2364–2381.
[48] W. Junqi, Z. Hu, Y. Zongkai, L. Yumei, Design of collaborative learning in cyberschools, in: 2009 First International Workshop on Database Technology and Applications, 2009, pp. 703–706.
[49] Z. Yijia, Research on mobile wireless network planning, in: International Conference on Communication Technology Proceedings, ICCT'96, 1996, pp. 342–346.
[50] M.F. Iskander, Z. Yun, Propagation prediction models for wireless communication systems, IEEE Transactions on Microwave Theory and Techniques 50 (2002) 662–673.
[51] R. Santos, O. Álvarez, A. Edwards, Experimental analysis of wireless propagation models with mobile computing applications, in: 2005 2nd International Conference on Electrical and Electronics Engineering, 2005, pp. 40–43.
[52] N. Baloian, J. Frez, G. Zurita, M. Milrad, Supporting engineering students learning wireless network planning using mobile, positioning and web technologies, in: Proceedings of the 12th IEEE International Conference on Advanced Learning Technologies, ICALT, Rome, Italy, Jul 4–6, 2012.
[53] G. Zurita, N. Baloian, F. Baytelman, A Collaborative face-to-face design support system based on sketching and gesturing, Advanced Engineering Informatics 22 (3) (2008) 340–349.
[54] N. Baloian, J. Frez, M. Jansen, G. Zurita, The role of HTML5 in mobile situated learning scenarios, in: Proceedings of the 10th World Conference on Mobile and Contextual Learning, Beijing, China, 18–21 October 2011.

Gustavo Zurita obtained his bachelor in Computer Sciences from the Universidad Mayor de San Simon in Bolivia. He obtained his Ph.D. in Computer Sciences from the Universidad Católica de Chile. Currently he is an associate professor at the Department of Management and Information control of the Faculty of Business and Economy of the Universidad de Chile. His main research topics are computer supported mobile collaborative learning, collaborative knowledge construction and geo-collaboration. He is an author of about 50 conference articles and 10 journal articles. Some of his journal articles are among the most cited ones in mobile computer supported learning in the world.

Nelson Baloian obtained his Engineering title in Computer Sciences from the Universidad de Chile and his Ph.D. from the University of Duisburg, Germany. Currently he is an associate professor and head of the Department of Computer Sciences of the Universidad de Chile. His main research topics are collaborative computer supported learning, mobile computing and geo-collaboration. He is an author of about 80 conference articles and 20 journal articles in these areas. He is a visiting professor at the University of Duisburg–Essen, Germany and Waseda University, Japan.

Jonathan Frez obtained his title of Engineering in Computer and Telecommunication from the Universidad Diego Portales, Santiago, Chile and a Master degree in Computer Sciences from the Universidad de Chile. Currently he is Doctoral candidate at the Computer Sciences Department of the Universidad de Chile. He is an author of 5 conference articles related to geo-collaboration and learning.