Inf Syst Front (2016) 18:125–144
DOI 10.1007/s10796-015-9580-3

Achieving better usability of software supporting learning activities of large groups

Nelson Baloian [1] · Gustavo Zurita [2]

Published online: 19 June 2015

Abstract Many business schools around the world offer courses to train their students in acquiring so called "soft skills", such as working in teams for decision making or sharing information to collaboratively solve complex problems. These courses often include learning activities where students are asked to generate ideas, discuss them, rank them and select the best ones. In order to develop their IT skills, students are often asked to take advantage of available IT technologies for supporting this task. If geographical location information is prominently used to provide context information about the ideas students propose and discuss, this activity can be classified as geo-collaborative. Free software available from the web has often been used to support this kind of work, like Google Maps, for geo-referencing the ideas, the text editor of Google Drive for describing them and Twitter or Facebook to exchange messages and comments. These applications are robust and suitable for use by large groups of students engaged in a situated learning activity. In the context of a learning activity taking place in a business school in Chile, the authors observed students for four semesters collaboratively using these tools to identify ways of improving life or solving problems in certain areas of the city which have to be georeferenced on a map. They had to generate proposals, discuss them and select the ten best. Through feedback provided by students, we identified problems regaring information overload, the lack of support for collaboration and unsatisfactory usability. From these findings we derived requirements for software especially designed to support this learning activity and have a tool that offers better usability. A prototype was developed to cope with these requirements. It was used for two semesters and evaluated under the same conditions when students used free and/or standard software. The experiment yielded positive results and gave us valuable insight on how to implement main features of a system supporting learning activities for large groups that includes decision making, blogging and geo-collaboration.

Keywords Geo-collaboration · Collaborative learning · Situated learning theory

1 Introduction

Nowadays, a professional person's success lies in being able to work in teams, which involves communicating, sharing, and using information to make decisions and/or solve complex problems collaboratively. It is also important for individuals to be able to innovate and be adaptive in order to respond to new demands and changing circumstances, while also being able to marshal and expand the power of Information Technology (IT) for creating new solutions, products and services, (Dede 2010; Griffin et al. 2012).

To prepare professionals with these skills, business faculties of various universities around the world offer undergraduate and graduate courses related to the use of IT to support business in all kinds of organizations. The content of these courses in the best business faculties (Quacquarelli, Cambridge, & Wharton), share a common approach which consists in students acquiring skills for identifying and understanding IT developments and knowing how to apply them to business

✉ Nelson Baloian
nbaloian@dcc.uchile.cl

Gustavo Zurita
gzurita@fen.uchile.cl

[1] Department of Computer Science, Universidad de Chile, Santiago, Chile

[2] Management Control and Information Systems Department, Universidad de Chile, Santiago, Chile

management in organizations. These skills are specified in the Standard Nr. 9 of the Learning and Teaching of the International Association to Advance Collegiate Schools of Business AACSB (AACSB 2014). Because of this, a meaningful learning activity is to identify problems and/or business opportunities associated with various components of the value chain of any organization that can be supported by IT. To achieve this learning goal, students are also expected to make use of diverse technologies, developing their IT literacy skills (Griffin et al. 2012). Teamwork is especially important for having various points of view when identifying problems/opportunities, as well as for searching for the solution, in order to generate ideas, to share them with the rest of the group, to discuss them and to select the best ones.

Additionally, various studies advise that learning goals should be achieved working in real scenarios or contexts (Drummond 2010; Lave and Wenger 1990). This allows students to identify the particular characteristics of the place where the problem and its solution apply, allowing for better understanding of the problem and its solution (Drummond 2010). In order to provide real contexts, we consider the collaborative geo-localization of the problems over a map a plausible requirement for the learning activity students have to perform. In this way, they can associate problems with their requirements posed by the physical surrounding. This can provide valuable information while searching for solutions with real added value. (Zurita and Baloian 2012). The collaborative work of students proposing ideas, geo-localizing them on a map and discussing them allows students to generate various points of view while identifying problems and their solution that otherwise would not be possible if they work alone. This will not only provide them with an environment where they can develop their team work skills but also with a favorable environment to generate diverse ideas for sharing their knowledge and opinions.

In line with what we previously discussed, at the Faculty of Business and Management of the Universidad de Chile students who take the "Information Technologies" course have to perform a learning activity in which they should identify opportunities to improve life or solve problems using information technologies. The ideas they propose should be associated with a certain physical area of the city. They have to generate, discuss and select the ten best ideas. We observed students performing this activity supported by free available software and services provided by various suppliers: they mainly used Google Maps for collaborative geo-referencing, Twitter and Facebook for communication and the text editor of Google Drive for managing shared textual information. However, opinion surveys performed after the learning activity have shown that the simple addition of all these tools and services was not the most suitable support for the activity. Problems that can be related to information overload, usability and collaboration support were reported.

This paper describes a systematic observation of how students use the available tools. It also registers their opinions about the advantages and drawbacks of using freely available tools and services. To support the task we derived the requirements for a software that solves most drawbacks of using these tools as they are. This was done by developing a new application that integrates the services offered by Google Maps and building upon it.

The rest of the paper is organized as follows: Section 2 discusses the state-of-the-art of the research areas, which are relevant to this work. Section 3 describes in detail the pedagogical activity proposed for achieving the desired learning goals presented at the beginning of this section. It also presents some examples of topics that have been presented and discussed by the students in various versions of the lecture. Section 4 presents the results of evaluating Google Maps usages and other free applications and services without modifications for supporting the proposed task during 4 semesters. Based on the evaluation obtained in the previous section, in Section 5 we derive the design requirement for a new application, and show the developed application and its evaluation using the same methodology as used for the evaluation described in Section 4. Section 6 concludes the paper.

2 Geo-collaboration, microblogging and decision making to support the pedagogical activity proposed

In this section we present the state-of-the-art of the related areas. The first one is geo-collaboration, especially when it is used to give context awareness to certain information. This is important for the learning activity we are considering since a pedagogical goal is for students to discuss problems that have a real context. The second one is microblogging, which are short messages people share within a group to report on something or express an opinion. This is pertinent for this learning activity since we have seen that students spontaneously discuss the ideas and select the best ones using this communication format when they are georeferenced. Models for decision-making in geo-collaboration scenarios are also relevant because students have to select the best proposed ideas. Finally, we review some works concerning usability of geo-visualization software.

2.1 Geo-collaboration facilitating context awareness

According to (Cai 2001; MacEachren et al. 2006) geo-collaboration is the modeling of collaborative tasks performed by a group of people involving the contextualization, construction and exchange of georeferenced data. This data is based on a human-computer interface that shows the map of the physical zone in the background, where the tasks are being performed and/or spatially contextualized by using mobile devices or desktop computers (Hill and Roldan 2005). The tasks may involve collaborative explorations and mapping of meaningful representations (MacEachren et al. 2003). This supports making geospatial decisions collaboratively in situations such as crisis management (Capata et al. 2008; Schafer et al. 2007); building planning (Convertino et al. 2007); and defining strategies (A. MacEachren et al. 2005).

Also, the geo-collaborative tasks may support the development of pedagogical practices to support learning. According to (Luo and Gao 2012; Silva et al. 2008; Zurita and Baloian 2012), conducting collaborative educational activities using geo-referencing data in authentic contexts enables students to establish significant cognitive relationships between what was seen inside the classroom and what is seen in a real context, (Lorna 2007). Furthermore, students may collaboratively work through learning tasks at the same time and in the same place (by social interaction in a real physical context), at the same time and in different places (social or virtual interaction in a remote context), at different times in the same place (virtual interaction in a real context), or at different times in different places (virtual interaction in a remote context). Geo-collaborative tasks supporting educational practices are based on the Situated Learning Theory, which states that learning requires theoretical concepts learned inside a classroom to be linked to practical and real situations in authentic contexts where they can be applied (Drummond 2010). Regarding this, (Lave and Wenger 1990) suggest that learning improves when knowledge is presented in a real and authentic context, i.e., settings which normally require that knowledge. Lave and Wenger (Lave and Wenger 1990), also claim that learning requires social or virtual interaction and collaboration among the students.

According to (Brown et al. 1989; Lave 1993; Vygotsky 1994), the way humans learn implies practicing the concepts acquired in theory. Vygotsky (Vygotsky 1994) explains that teaching activities involving conceptual content (learned inside a classroom) and implementation (in real situations) are not only complementary, but also serve as feedback to each other in a process of ongoing and increasing interaction. This means that learning is acquired in and outside the classroom through social interaction and constructions (Brown et al. 1989). Situated learning scenarios can be supported by collaborative software applications installed in wirelessly interconnected mobile devices (Zurita and Baloian 2010). These applications can geo-reference diverse data and information such as texts, pictures, files, etc., at concrete physical locations where the knowledge is required. Other functionalities of these applications are: recording the history of the routes; taking notes on real geographic zones; determining routes; comparing different notes made in different locations; exploring and reporting collaboratively on what is happening in their environment, (Silva et al. 2009; Srivastava and Tait 2012); and personalizing the learning experience of each student (Benford 2005);.

2.2 Microblogging to support communication in a learning environment

According to (Java et al. 2007), the use of Twitter – the most popular microblog today – may promote the formation of online communities and facilitate the interaction among learners through the exchange of text messages associated with photographs, documents and videos on the internet.

Microblogging services have been introduced in various educational scenarios and the evaluations of these experiences report two benefits for the learning process: a) ease of use, and b) the positive impact in various pedagogical practices. In (Grosseck 2009), authors report that the complexity level for using microblogs is low and independent of the computer device being used. Normally, a computer, with a browser and internet connection is enough. Moreover, microblogging services are available for continuously used over an extended period of time, allowing easier and faster access to information when and where it is needed. These characteristics allow curriculum designers to focus on the development of the didactics instead of on problems related to the use of the microblogging platform. Various authors have found that its use positively influences important learning aspects like collaboration (Altamirano et al. 2009; Holotescu and Grosseck 2010), creativity (Altamirano et al. 2009), development of communication skills (Altamirano et al. 2009; Holotescu and Grosseck 2010; Luo and Gao 2012), rising ICT Literacy, as well as the productivity in the generation of ideas and self-direction (Altamirano et al. 2009; Holotescu and Grosseck 2010). Additionally, it has been found to promote Lifelong Learning (Altamirano et al. 2009; Grosseck 2009) and the insertion of users in communities of practice (Dunlap and Lowenthal 2009; Holotescu and Grosseck 2010).

In the literature we found benefits of using microblogging in learning scenarios:

- The use of microblogs with mobile devices meets the necessary requirements to be introduced in educational contexts: accessibility, immediacy, interactivity, and situating of instructional activities, (Chen et al. 2002).
- Students get feedback on their comments (Altamirano et al. 2009; Ebner et al. 2009), feeling motivated to keep virtual and face-to-face discussions (Ebner et al. 2009; Silva et al. 2009) with their classmates, get information (Ebner et al. 2009; Grosseck and Holotesku 2008) keep informed on what is happening in their courses in a fun way (Altamirano et al. 2009; Grosseck and Holotesku 2008), and develop competencies to transmit relevant and summarized information, (Grosseck and Holotesku 2008).
- Microblogging has a positive influence in the process of argumentation and discussion (Grosseck and Holotesku 2008); favors students reflection processes (Ebner et al.

2009; Grosseck and Holotesku 2008); supports collaboration (Altamirano et al. 2009; Holotescu and Grosseck 2010), creativity (Altamirano et al. 2009), critical thinking, development of communication skills (Altamirano et al. 2009; Holotescu and Grosseck 2010; Lin et al. 2010) productivity (Dunlap and Lowenthal 2009) and self-direction (Altamirano et al. 2009; Holotescu and Grosseck 2010).
- Encourages the construction of communities of practice allowing the acquisition of social/cultural skills (Altamirano et al. 2009; Dunlap and Lowenthal 2009; Grosseck and Holotesku 2008; Holotescu and Grosseck 2010; Stepanyan et al. 2010).
- Motivates students to feel more comfortable raising and answering questions they would not dare in class (Borau et al. 2009; Junco et al. 2011). f) Teachers rely on a space for discussion outside the class (Junco et al. 2011), increasing its dynamics (Altamirano et al. 2009; Borau et al. 2009), offering direct and immediate feedback to students (Borau et al. 2009; Ebner et al. 2009), and favoring the inclusion of students in the real world (Grosseck and Holotesku 2008).

We also found some disadvantages (Grosseck and Holotesku 2008):

- High volumes of non-relevant information in the educational process distracted students.
- Lack of courtesy in communications.
- Because of the 140-character limit, messages are written in coded and abbreviated terms, which are often grammatically incorrect.
- Teacher not available to provide feedback to students through the microblog.

Finally, information generated in a microblog can be efficiently used to support virtual decision-making processes, (Shum et al. 2011; Turban et al. 2011). Researchers report in (Java et al. 2007; Zhao and Rosson 2009) that the reasons people give for using microblogging are: a) to keep in touch with others, b) to promote certain kinds of interesting information, c) to ask questions and leave comments. These reasons are at the core of the proposed learning activity described in Section 1. In summary, microblogging supports collaborative work, communication, creativity, brainstorming, ranking and selecting proposals. These activities are at the core of the proposed learning activity.

2.3 Models for decision-making process in geo-collaborative environments

Group decision-making is a collaborative effort performed by a team of individuals to accomplish certain tasks or attain a goal. It involves a series of social interactions, for example, communication, deliberation, and activities such as generating ideas, asking and answering questions, making comments, searching information, or selecting ideas. These interactions may or may not be mediated by computer technologies. The process of decision-making has been the subject of research for decades. The work presented in (Wong 1994) proposes the Cooperative Decision Making model, that emphasizes the importance of negotiating conflicts (Identification → Processing → Negotiation). The Participatory Decision Making model (Kaner 1996) distinguishes between divergent and convergent collaboration modes (Divergent → Groan → Convergent → Closure). The Collaboration Engineering model (Briggs et al. 2003) synthesizes decision-making as a collection of behavioral patterns that may be "engineered" to respond to contextual situations (Diverge, Organize, Evaluate, Build consensus, and Converge).

As mentioned in (Antunes, Sapateiro, Zurita, and Baloian 2010; Turban et al. 2011), decision-making seems to be organized according to three main decision-making patterns: (1) information gathering and brainstorming of ideas in a divergent mode; (2) finding alternatives, commenting and processing them using divergence and convergence modes; and (3) making choices in a convergent mode. In our case, we consider the subset of fundamental requirements of geo-collaborative decision-making processes proposed in (Antunes et al. 2010):

- Perception support, Geo-collaborative decision-making tools should associate georeferenced data with adequate perception mechanisms, like pictures and text descriptions, organizing them in sequence, for the purpose of facilitating the contextual representation and understanding of an idea (Holtzblatt et al. 2004; Van der Lelie 2006).
- Retention support. Retention is a fundamental driver to construct individual and group memory and contributes to enacting adequate responses whenever recognizable situations emerge. Geo-collaborative decision-making tools should therefore maintain a repository of the georeferenced data, their comments and rakings.
- Externalization support. Externalization is essential to information gathering and brainstorming of ideas, since knowledge is constructed by articulating tacit knowledge into shared explicit expectancies, cues, goals and actions.
- Divergent/convergent support. The decision-making process involves cycles of divergent and convergent activities, where divergent activities favor problem identification and information gathering, and convergent activities promote the negotiation and selection of alternatives.
- Task/pattern management. The decision-making process seems to be organized according to a set of patterned activities such as divergence, convergence, data organization, option evaluation, etc. Geo-collaborative decision-making tools should carefully avoid prescribing rigid structures.

2.4 Usability in geo-collaborative applications

According to (Robinson et al. 2005) usability has been a growing topic among scientists concerned with Geographical Information Systems (GIS), since they say that "functionality alone is insufficient assurance that a tool is applicable to a problem in situ" and that developers of these tools should take some lessons from interaction designers and usability experts and apply their techniques to GIS tools in order to maximize this ability. A number of articles dealing with this subject in recent years confirm this idea (Richards 2015; Fonte et al. 2015). In (MacEachren and Kraak 2001) authors highlight the need to "to develop a comprehensive user centered design approach to geo-visualization usability." In (Slocum et al. 2003), the authors present a six-stage design process for the creation of a user centered tool to visualize issues related to water balance. However, (Robinson et al. 2005) regret that in the six-stage process presented by (Slocum et al. 2003) there is a "lack of early and repeated user input in their discussion of results". Their recommendation is that user participation should happen from start to finish, rather than after key elements have been decided by developers.

3 Evaluating the use of Google maps and other services from "the cloud" as support for identifying problems and/or opportunities for technology-related business

In this section we describe the learning activity performed by the students four times, in four consecutive semesters during the years 2011 and 2012. They used Google Maps without modifications for geo-referencing ideas they propose and any other available tool or service they wanted in order to communicate and synchronize their work. First we present a more detailed explanation of the task, and then the characteristics of the technical setup, as well as the methodology used to gather data. After this, three examples of interesting proposals generated by the students are described. We then present the results of the questionnaire which was applied to the students at the end of the learning activity, that consisted in three questions on whether or not they experienced information overload; how easy was it to use the tool and how good was the collaboration support provided by the tool? This section also shows examples of which other tools and services they used to coordinate their work beside Google Maps. We used the same methodology and experimental design and applied a questionnaire similar to that utilized in the work by (Antunes et al. 2011), where the main goal was to obtain quantitative and qualitative insights on how large groups collaborate. However, for the work reported in this paper, the results were analyzed for a different purpose: this time the focus was to find out which functionalities were missing or not properly supported to accomplish the tasks.

3.1 Task description, sample, technical setup and data collection methodology

The experiment involved students from an undergraduate course undertaking a collaborative assignment that consisted in identifying realistic problems and/or opportunities in an urban area and proposing innovative solutions based on information technology. Students were asked to wander around an urban area near the campus in order to accomplish this "Situated Learning-type" task.

This assignment was applied four times; each semester starting the first semester of 2011 and ending the second semester of 2012. The sample consisted of 50, 48, 48 and 46 students, for each semester; 30, 26, 24 and 28 male; average age 23.3, 22.8, 23.1 and 22.3 respectively. They were taking an undergraduate course on Information Technology for Business in the eighth semester of the Information and Management Control Engineering degree program of the Economics and Business Faculty of the Universidad de Chile. The expectation is that students taking this course are able at the end of the course to: (a) detect problems and identify opportunities in an organization that may be supported by Information Technology (IT); (b) manage an IT strategy that can introduce competitive advantages into an organization; (c) design IT solutions for a business project; and (d) develop communication and teamwork skills. These students are good users of computing technology: 55 % use notebooks or tablets in classes and most have smartphones. All of them have a PC at home. They regularly use popular desktop software and use social media tools like Twitter, Facebook, and Skype.

Regarding the technical setup, the task was performed collaboratively outside regular classes. All students were part of a single team. The teacher explained the assignment in the classroom, recommending that the students observe an area and identify realistic problems, opportunities and ideas that may be addressed using IT, that should be georeferenced in Google Maps. Each student should deliver at least two ideas. Students were also asked to discuss and give their opinions on their classmates' ideas. They also had to collaboratively choose the ten best ideas by mutual agreement and had 1 week to perform the task. They were given no instruction regarding the type of hardware to be used for this task. There was also no recommendation about what to use as coordination mechanism for the process of collaboratively selecting the best ideas. The students were given no other instruction other than to use Google Maps, though they were allowed to use any other tool they wanted to communicate and synchronize their work. Consensus rules, task awareness and coordination mechanisms had to be established by the students themselves. Following the instructions, students performed the assignment accordingly. Pictures taken with mobile phones, cameras or even taken from Street Views were uploaded to Google Maps. A documentation of these activities is shown in Fig. 1.

From these experiences, we collected data from the questionnaires that students filled out at the end of the activity. For this work, questionnaires and the subsequent analysis were organized in three major categories, namely information overload, usability (ease of use), and collaboration support. As in (Antunes et al. 2011), we organized the questionnaires and the subsequent analysis in five major categories, namely group size, information overload, collaboration and usability, grounded on a subset of the design dimensions defined by Driskell (Driskell and Salas 2006). The strategy we adopted to analyze the results consisted in starting with an analysis of quantitative data and then using the open questions to validate the results and find additional insights. The responses to the open questions were sequentially analyzed and coded in two rounds, the first one aiming to identify relevant codes and the second one to revise codes and improve the quality of the coding process. The coding was made by two persons. They worked collaboratively and reported that there was a high degree of agreement when assigning values to the answers given by the students. The people participating in the coding process were the same for the two rounds. The adopted coding strategy was a mix between grounded and start list (Miles and Huberman 1994): the categories emerged during the coding process, but they were confined to two master codes, namely positive and negative factors. After the second round, the number of occurrences of each code was counted. This served to quantitatively point out which codes were more relevant to the analysis.

Although the students were instructed to use Google Maps they also used Google Drive (spreadsheet, and text processor) collaboratively in order to support the discussion and convergence process. For this reason we additionally analyzed the students' usage of these tools to identify which processes and data structures were the most frequently used in order to obtain additional functional requirements.

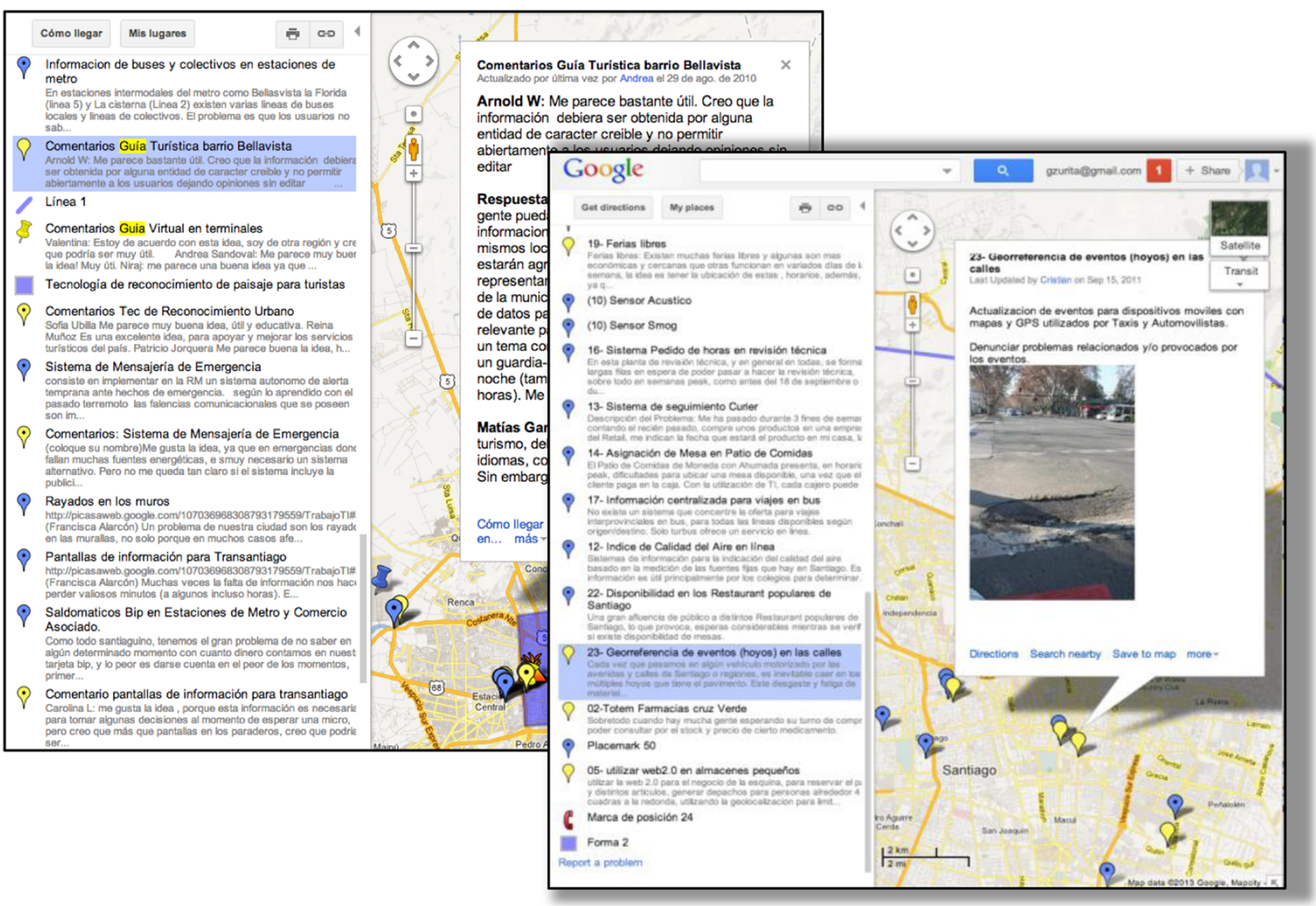

Fig. 1 Two Google maps instances collaboratively georeferenced by the students (2nd semester of 2011 on the *left*, and 2nd semester of 2012 on the *right*). The list of ideas is shown on the *left side*. Geo-references are displayed as icons on the map representing the location for these ideas. Text and pictures describe ideas presented by students. The screenshot on the *right* shows the interface with a georeferenced idea showing the associated comments. This layout was not effective for supporting collaborative discussion among students

3.2 Some real examples identified in the pedagogical activity

In order to illustrate the outcomes of the described learning activity, we present some of the proposals the students generated after applying the decision-making processes using georeferenced information in downtown Santiago.

Bus terminal without proper information This proposal geo-references one of the bus terminals in Santiago for passengers travelling to various cities, indicating that there is no precise information available about the platform from which the buses depart. This generates confusion and nervousness among the users, especially when the platform for a departing bus changes. Information about changes is announced by oral messages using low-quality loudspeakers and without repetition. As a solution to this problem, a student proposed installing screens over each platform displaying relevant information about destinations, departure times, etc. To illustrate the idea the student uploaded two photos from the platforms. The classmates commented on this proposal by adding that in order to help users, new information should be displayed in cases of delayed departures. Other classmates suggested displaying this information on a web page that can be accessed by cell phones. Others support the proposal, adding that passengers usually have heavy luggage, that hinders them from moving swiftly from one platform to another.

Supermarket lines / queues A student raised the issue of clients having to line up for too long to pay in a supermarket located in downtown Santiago, adding that this is a common problem in almost all supermarkets located nearby. The situation is illustrated with photos from lines formed in front of the cashier. The proposed solution was a geo-collaborative application running on smartphones in which customers can see the current status of the lines in the supermarket, including expected waiting time. Some comments from classmates suggest that this application could be implemented as a social network, in which members can report on the state of the supermarket lines. Another comments that the same application could be used in similar situations where clients or users of services have to line up to be served, such as in banks. A third student suggests the development of a business model based on subscription and advertisement to make profit.

Information on reversible traffic lanes In Santiago there are certain streets, depending on the time of day, that are delegated as one-way or two-way directions in the benefit of better absorbing rush hour traffic. On this topic a student considers it necessary to provide more information to drivers who do not usually take these routes. To introduce this discussion topic, the student geo-references one of the most important streets with this characteristic in Santiago, adding that there are 47 other streets working this way. As a solution the student proposes a georeferenced application that according to the driver's location, reports whether there are reversible traffic lanes nearby and in which direction are they set at that time. It may also suggest alternative ways for the final destination. Some students responded to the proposal suggesting to install more digital billboards that inform drivers on the lanes and their reversibility. Another student supported the idea reporting that he has witnessed more than one accident because of unaware drivers taking the street in the wrong direction.

3.3 Findings of the experiment

As we mentioned, from the questionnaire applied in (Antunes et al. 2011), we only take into account the next three open questions: Q1: "Did you experience information overload during the task?", Q2: "How easy to use was the software itself", and Q3: "How easy to use was the collaboration support?" Students were asked to comment and describe positive and negative aspects of the software they used related to the question. The results of the qualitative analysis of the data obtained are shown in Tables 1, 2, and 3.

As seen in Table 1, the most negative comment about information overload was associated with the difficulty in identifying and following the many ideas generated and their associated comments. On average, 17 students mentioned this problem each semester. Students mentioned that using only Google Maps as instructed made it difficult to aggregate all comments made for one idea. In the 4 semesters students used additional documents from text editor of Google Drive for writing their comments (see Fig. 2 left). As mentioned before, the text editor and the spreadsheet of Google Drive were used to collect the comments. Mechanisms used to associate ideas in Google Maps to the comments were: a) repetition of the title and/or description of the idea (see Fig. 2 on the right) b) generation of an identification number for each idea (see the numbers associated with ideas in Fig. 2).

In all cases the number of generated comments made it difficult to follow and read them completely. Many students mentioned they read only a subset of the ideas and comments because they were simply too much. They also indicated that it was difficult to find the new ideas and comments out of the old ones, as well as finding a certain idea or comment in order to read it again. It was even more difficult to associate the georeferenced information in Google Maps with the ideas and comments in Google Drive. Only during the second semester of 2012 students tried to associate comments with the corresponding idea in the same document in Google Maps. Students started to write their comments just after the text written as information to the georeferenced idea, adding their names to the comment. However, additional Google Drive documents were used to implement the selection and vote

Table 1 Qualitative coding of student answers to the questionnaire and the frequency in which they were mentioned associated with Q1. S1=Semester 1. S2=Semester 2. Avg 4=Average of 4 semesters (S2, S1 of 2011; S2, S1 of 2012)

Q1: Did you experience information overload during the task?

Positive comments

	Year/Semester				
	2012		2011		
Avg4	S2	S1	S2	S1	
1.8	3	2	0	2	Everyone was available on the computer screen.
2	2	2	3	1	Work was performed in an orderly fashion.
1.5	3	0	1	2	History of ideas was easy to follow.

Negative comments

	Year/Semester				
	2012		2011		
Avg4	S2	S1	S2	S1	
16.8	21	12	15	19	Too many ideas and comments shown at the same time.
6.5	5	8	7	6	Some contributions were duplicated.
10.5	16	14	10	2	Considerable flow of ideas and feedback.
9.3	14	8	9	6	Relation between ideas and comments difficult to establish.
11.5	12	15	12	7	Related ideas are shown apart from each other.
4.8	5	4	8	2	Too many objects shown in the same window at the same time.
7.3	12	9	6	2	Some comments were simply forgotten.

for the best ideas. The result of having comments separated from the ideas implied that the high flow of ideas and their comments that were created were difficult to follow and easy to forget (10.5 on average); and therefore, the number of repeated ideas was considered high and that they were difficult to detect (6.5 on average); or that it was easy to forget the comments they already read due to the high number of proposals and comments (7.3 on average). Few positive comments were expressed. The most relevant was that the participants liked having all information available on the computer screen. Comments on Q2 reveal several technical issues contributing to the perceived low usability (see Table 2).

The most negative comment was related to the lack of mechanisms to easily associate the georeferenced ideas and the corresponding "conversation" resulting from the comments given to it (average 10.5). In fact, the lack of this kind of functionality was the reason given by the students for having to use additional documents (text editor or a spreadsheet) in Google Drive.

Table 2 Qualitative coding of students' answers to the questionnaire and the frequency they were mentioned associated with Q2. S1=Semester 1. S2=Semester 2. Avg 4=Average of 4 semesters (S2, S1 of 2011; S2, S1 of 2012)

Q2: How easy was the software itself to use?

Positive comments

	Year/Semester				
	2012		2011		
Avg4	S2	S1	S2	S1	
8.3	8	9	6	10	Easy to understand.
2.3	4	0	2	3	Immediate visualization of new comments.
3.5	5	3	4	2	Reference of ideas in geographical context.
1.3	2	0	1	2	Use of colors.
3.5	6	2	4	2	Use of text and pictures.
1.8	1	2	3	1	Use of icons.
1.5	0	2	3	1	Easy access to ideas.
0.8	0	2	0	1	Searching.

Negative comments

	Year/Semester				
	2012		2011		
Avg4	S2	S1	S2	S1	
6.5	6	7	5	8	Proximate comments are difficult to discern.
7.3	10	5	8	6	Cannot see who deleted comments.
11	12	10	15	7	Lacks coordination support.
10.5	14	12	10	6	Mapping and chatting unrelated.
1.3	0	2	1	2	Slow.
6.3	8	9	6	2	No private working space.
9.3	13	11	9	4	Had to improvise in order to collaborate.
8.5	9	12	8	5	Difficult to merge comments, ideas.
8	11	7	9	5	Communication is not primarily focus.

Table 3 Qualitative coding of students answers to the questionnaire and the frequency they were mentioned associated with Q3. S1=Semester 1. S2=Semester 2. Avg4=Average of 4 semesters (S2, S1 of 2011; S2, S1 of 2012)

Q3: How easy to use was the collaboration support?

Positive comments						Negative comments					
	Year/Semester						Year/Semester				
	2012		2011				2012		2011		
Avg4	S2	S1	S2	S1		Avg4	S2	S1	S2	S1	
3.8	6	3	2	4	Shared view of ideas.	12.8	16	9	12	14	Group had to develop alternatives for coordinating group work.
1.3	2	2	0	1	Eases problem understanding.	11.5	15	11	8	12	Users can edit others' contributions.
0.8	2	0	0	1	Facilitates view of task progress.	8.3	11	6	9	7	Tool inadequate for discussion support.
1.8	3	2	0	2	Permits asynchronous interaction.	4.8	6	3	5	5	Difficult to converge.
1.0	2	1	0	1	Eases time management.	8.5	12	9	7	6	Asymmetric participation.
0.5	0	0	1	1	Uses colors.	2.5	4	3	1	2	Lack of chat tool.
						7.3	9	8	7	5	Lacks awareness mechanisms.

The analysis of Q1 that focused on information overload revealed that the most important negative aspect was that it was difficult to follow the ideas and the associated comments. Q2 revealed that from the usability point of view the most negative aspect was the association of the ideas written in Google Maps with their comments in Google Drive documents. An interesting result of the analysis was that in three of the four semesters the students tried to structure the information in Google Drive in a similar way that a microblogging service would do: short messages arguing for or against the proposition (see Fig. 2).

The second negative aspect is related to the lack of coordination support (with a frequency of 11 points on average). On some occasions a coordinator was elected by the students who would mediate when defining deadlines for generating idea proposals, number of comments expected and deadlines for generating them, voting mechanisms, etc.; because neither Google Maps nor Google Drive provide such mechanisms. One of the most cited arguments about lack of coordination mechanisms was that in Google Maps all ideas would seem to have the same relevance and only after carefully reading all comments they would find which ones were the most preferred.

The third negative comment with a frequency of 9.3 points is associated with the need to improvise collaboration strategies, since the tool does not offer clear support in that area. Students missed a functionality that could help them count favorable and unfavorable comments given to an idea. In order to overcome this problem, in three of the four semesters, students used a spreadsheet from Google Drive instead (see Fig. 3). In one semester they used a simple table made with the help of the text editor (see Fig. 3 to the right).

The next negative aspect (average frequency of 8.5) was the difficulty to combine ideas with their comments in a single view. This aspect can be clearly seen from the screenshots shown in Fig. 1 showing the georeferenced proposals and the one in Fig. 2 showing the Google Drive document with the comments. Even when in one semester students did write the comments in the same place with the ideas on Google Maps (see screenshot on the left of Fig. 1), they were afterwards copied into a document for rating, as seen in Fig. 3. This also explains the high frequency (8.0) of negative comments expressing that there was no simple communication mechanism for commenting on the ideas, expressing preferences and rating.

Other negative aspects mentioned were that any student could modify or even delete the contributions made by another (7.3), difficulties for differentiating comments when their georeferenced locations in Google Maps was near (6.5), and the absence of private workspace before publishing the ideas (6.3). The most relevant positive aspect mentioned was that Google Maps was easy to use.

An interesting aspect was that many of the ideas that were also presented in Google Drive were extended, in comparison to the one that was georeferenced in Google Maps. They were described with more detail, sometimes taking the format of storyboards in order to give better context to the idea. (Holtzblatt et al. 2004; Van der Lelie 2006). Table 3 shows the students' stand regarding the question Q3, i.e., how easy to use was the collaboration support provided by the system?, with clear emphasis on the negative side. Two reasons were very prominent: a) the group had to develop coordination and a collaborative mechanism (using Google Drive) since Google Maps "as it is" does not provide any (12.8); and b) the problem that any participant may modify or delete comments without control or rollback (11.5).

Students mentioned that they had to resort to mechanisms defined by them to synchronize their work, like establishing

Fig. 2 At *left*: extract of a Google Drive document with the proposition of an idea and the associated comments. At *right*: The screenshot behind, shows a Google Maps document with a proposal identified by the number 23. The screenshot at the front shows a Google Drive document with this number, the same title, some photos and the description of the proposed idea, and microblogging–like comments

deadlines for proposing, commenting on and ranking the ideas. Despite this agreement many students expressed their preference to work without deadlines. Many students also suggested that the time period for making comments on ideas should be immediately after their publication, otherwise they might forget what they wanted to say after reading it if they have to wait for that. Students expressed that geo-referencing ideas over a map was a good way to give context and with this, aid in understanding of the problem or opportunity the idea was tackling. They mentioned that using one system for geo-referencing ideas and then another for discussing them was rather inefficient, since they had to manage two systems and input the same information twice. According to the students, the information generated for Google Maps, as well as for Google Drive, should not be collaboratively editable in order to avoid that students modify opinions of their classmates.

4 Design requirements of a new geo-collaborative application based on Google maps

In this section we will describe general and specific requirements of the application. The general requirements are based on the literature review presented in Section 2 that will be labeled as Gx (x being the number of the requirement). The specific requirements are those we derive from the questionnaires applied to the students after using Google Maps without modification that will be labeled with Sx.

General requirements associated with microblogging as support for communication for pedagogical geo-collaborative applications are (see Section 2.2):

G1 The communication mechanism should be simple and with similar structure as the microblogging short messages. This communication structure will be used to textually describe

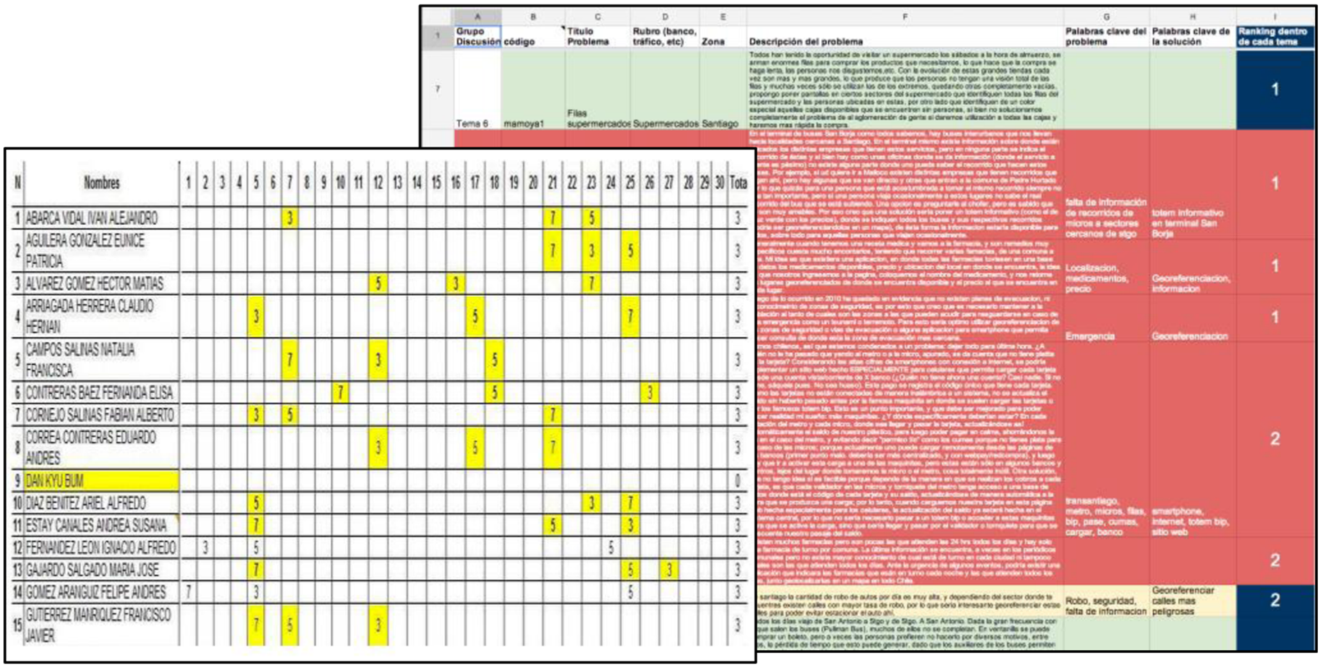

Fig. 3 At the *left*, a screenshot of the matrix students confectioned using Google Drive. Each row corresponds to an idea and the columns to the rating given by one student to that idea. At the *right* a screenshot of a text written with Google Drive with a table where each row corresponds to a student and the columns to a subset of relevant pre-selected ideas that will be ranked; students evaluated each idea with a number from 1 to 7

the problems and opportunities and their solutions; it will facilitate discussion and argument for or against these ideas with the goal of deciding on the best one.

G2 The microblogging communication type should favor the generation of short, clear and simple interaction messages. However, the system should be easy to extend if more information is required.

General requirements associated with decision-making processes in geo-collaborative applications supporting learning are (see Section 2.3):

G3 Students should be able to georeference points, regions or lines over a map and associate information (text, pictures, etc.) to these elements. This will support the process of information gathering and brainstorming in a divergent mode.

G4 Students should be able to argue and comment on ideas proposed by others. This will support the generation of alternative ideas.

G5 Students should be able to express their own preferences for the proposed ideas. The system should provide a simple mechanism to sort out the best ones. This will support the process of selection of alternatives.

Specific requirements derived from the previous section are associated to the answers to the three questions. Requirements associated with the question about information overload Q1 are:

S1 Provide mechanisms for making comments and selecting ideas in the same place where they are georeferenced (brainstorming);

S2 Provide functionalities to support a student to follow ideas being discussed. This will be implemented by searching mechanisms.

Requirements associated with the question about information overload Q2 are:

S3 Provide microblogging-like information architecture for the ideas, so it will be easy to identify positive and negative opinions for each idea.

S4 Provide selecting mechanisms (voting and/or rating) to support the convergence stage in the decision-making process.

S5 Provide mechanisms to manage private working spaces whose content can be later published.

S6 Implement editing rights so that students do not modify or delete comments or ideas that are not their own.

S7 Provide functionalities that allow students to write their idea proposals as “storyboards”.

Requirements associated with the question about information overload Q3 are:

S8 Provide a collaborative workspace that allows students to propose their georeferenced ideas enriched by text and images (brainstorming and storyboarding), comment on them (in divergence and convergence modes); and state their preferences (convergence).

S9 Include brainstorming, divergence, and convergence processes in an iterative and cyclic way, allowing students to propose ideas, comment on them and/or rate them during all the process.

Table 4 shows the relationship between the specific and the general requirements. An x in a certain cell [Sx, Gx] of the table represents that the implementation of the specific requirement Sx contributes to the fulfillment of the general requirement Gx. For example, implementing S1 contributes to fulfilling G1, G2, y G3.

5 Geo-collaborative application proposed to tackle problems related to the use of Google maps and Google drive documents

In this section we describe an application that uses geo-collaboration and microblogging-like messages to support the pedagogical activity described in Section 1, whose design is based on the general and specific requirements presented in Section 4. The application has been developed with HTML5, thus users only need a computational device with a browser and an Internet connection to run it. Therefore, the application can be used on mobile devices, desktop computers, or tablets without major variations in its functionalities. Views are of course adapted to fit in the screens with different sizes. The application incorporates Google Maps functionalities through the API provided by Google and implements the necessary additional functionality in order to support students' work according to the requirements derived in the previous section.

Table 4 Relationship among general (Gx) and specific requirements (Sx)

Specific requirements (Sx)	General requirements (Gx)				
	G1	G2	G3	G4	G5
S1	x	x	x		
S2		x	x		
S3	x	x			
S4					x
S5					x
S6					x
S7		x		x	
S8	x		x	x	x
S9				x	x

5.1 Description of the geo-collaborative application

Figure 4, shows the main view of the proposed geo-collaborative application as seen on a screen of a mobile device (smartphone) or a desktop computer. In this section, we describe the application according to the identified general and specific requirements (see Section 4 for more details). The functionalities of the application can be classified according to which stage of the decision making process they support: 1) Information gathering and brainstorming, 2) generating options and discussing them and 3) make decisions (select the best options).

(1) Information gathering and brainstorming in a divergent mode. Students start the learning activity by inputting new ideas or browsing the ideas already proposed. Each proposal is first created in a private workspace or view and only after completing the proposal, it can be shared with the rest of the students in order to be commented on and/or ranked (see design requirement S5). Students start creating a new proposal using the geo-referencing functionality in order to put location marks, regions (circles, rectangles), or lines over the map that describe the physical location or area with which the idea is associated. The options for geo-referencing information over the map can be seen in the upper central part of the desktop computer's screenshot in Fig. 4, as well as in the mobile device's screenshot in the same figure. In addition to the location, the student has to input a title, a textual description (mandatory), and pictures in order to better contextualize the proposal (optional). It is possible to associate even more context information with a proposal, activating the Street View functionality of Google Maps, as shown in Fig. 5.

Because of the characteristics of Street View, only georeferenced points (not lines or areas) can be seen using this perspective.

Students who log in to the application will see at first a list of the proposals input so far, which they can select and see its content (the geo-location, title, description and photos) and also explore the Street View perspective. Proposals that have been are also shown on the map and can be selected by clicking on the location mark, region or line that was used to geo-reference it. The title and description on the left-hand side is always associated with a selected location on the map. Selecting another proposal or starting the creation of a new one will also change the associated description. In this way we tackle design requirement S1. Picture descriptions may correspond to a sequence of situations describing the context of the proposal using a story-board fashion to better understand it, see Fig. 6 (see design requirement S7). The number of pictures is not limited and they may be

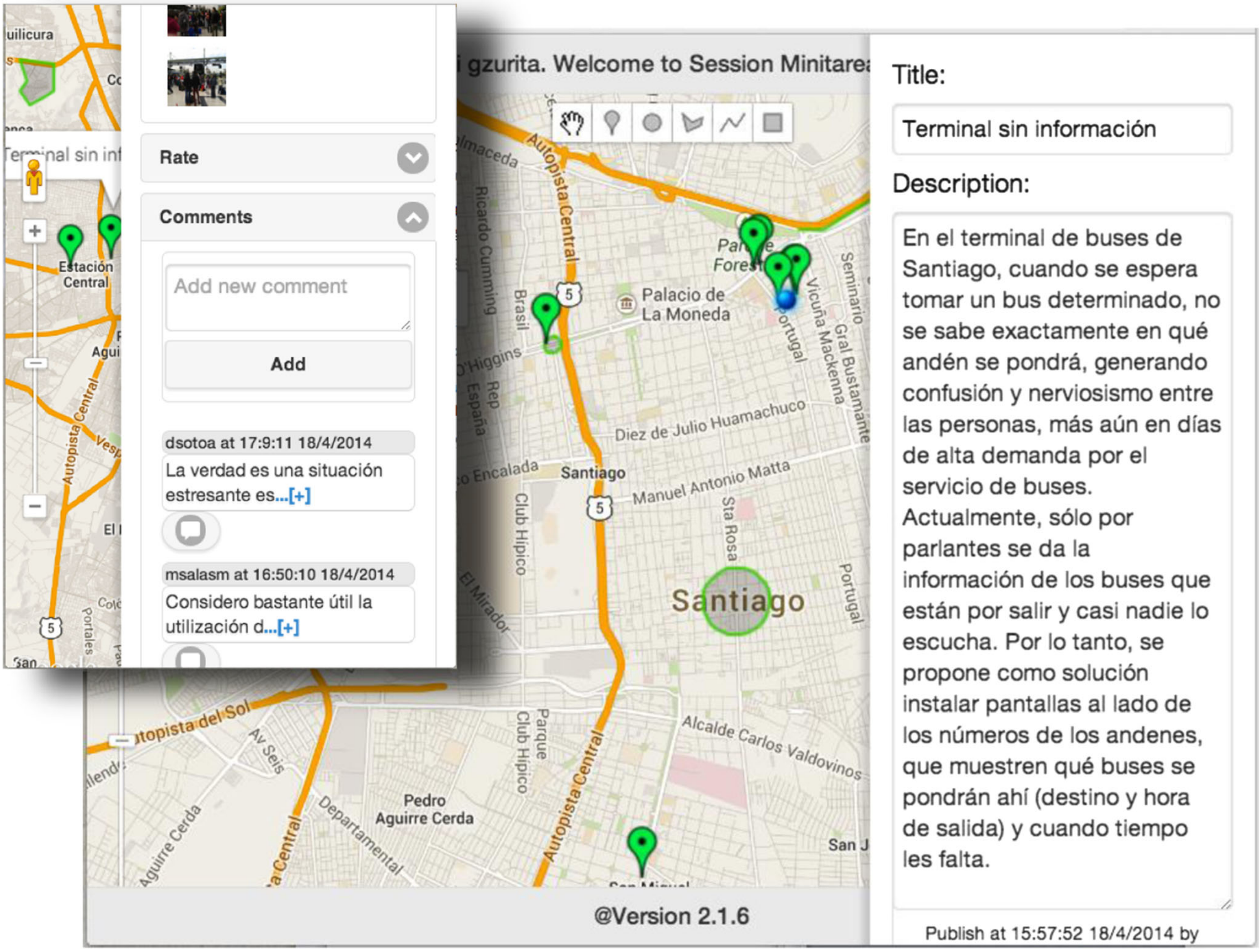

Fig. 4 Two screenshots of the application, both showing the same proposal named "Terminal sin información" whose label can be seen over one of the pins over the map. The small screenshot is taken from a Smartphone, showing two pictures in the upper part (shown larger on Fig. 5) showing information for raising context awareness for the proposed idea. Below the pictures are options to rate (not expanded), and leave comments on it (expanded); the big screenshot is taken from a desktop computer screen and shows the title and detailed description of the idea

uploaded from a desktop computer or a mobile device camera, thus allowing a student to create a proposal, write the text and take the picture on the spot and upload it attaching the geo-location automatically using the GPS of the mobile device, if present. Pictures will be shown using at most, half of the left-hand-side area of the interface in order to leave enough room for the text description and the comments other students make to it (see design requirement S8). In the desktop view of the interface shown in Fig. 4 a georeferenced proposal labeled with "Terminal sin información" text is shown, that means, this contribution is currently selected by the user for viewing, adding a comment and/or rating it. The icon showing an open lock beside the proposal's title means it has already been made public.

(2) Finding and commenting alternatives, information processing using divergence and convergence modes. In order to support students in reviewing and commenting on the various proposals, a searching tool was incorporated in the application because location of contributed ideas was mentioned as a problem and was the cause for establishing design requirement S2. The screenshot in the middle of Fig. 7 shows the searching tools of the mobile device interface. Contributed ideas can be searched by author name, words within the comments or creation date. The result of the search is shown as a list under the search tool and the corresponding location of all proposals matching the search criteria are shown on the map. Comments associated with the ideas follow a microblogging structure as stated by design requirement S3. This can be seen at the bottom right part of the mobile device interface in Fig. 4, where two comments were made on this idea are shown. The selection/review of comments is based on simple scrolling and options

Fig. 5 This picture shows the Street View perspective of the labeled "Terminal sin información". The pin behind the bus corresponds to the proposal geo-referencing. This view helps to improve the context awareness for the proposed idea. The user reaches this view applying the Street View functionality on a georeferenced mark over a street

Fig. 6 Two images belonging to the "Termnal sin información" proposal uploaded by a student in order to improve the context awareness of the proposal. These images correspond to the central idea shown in Fig. 4

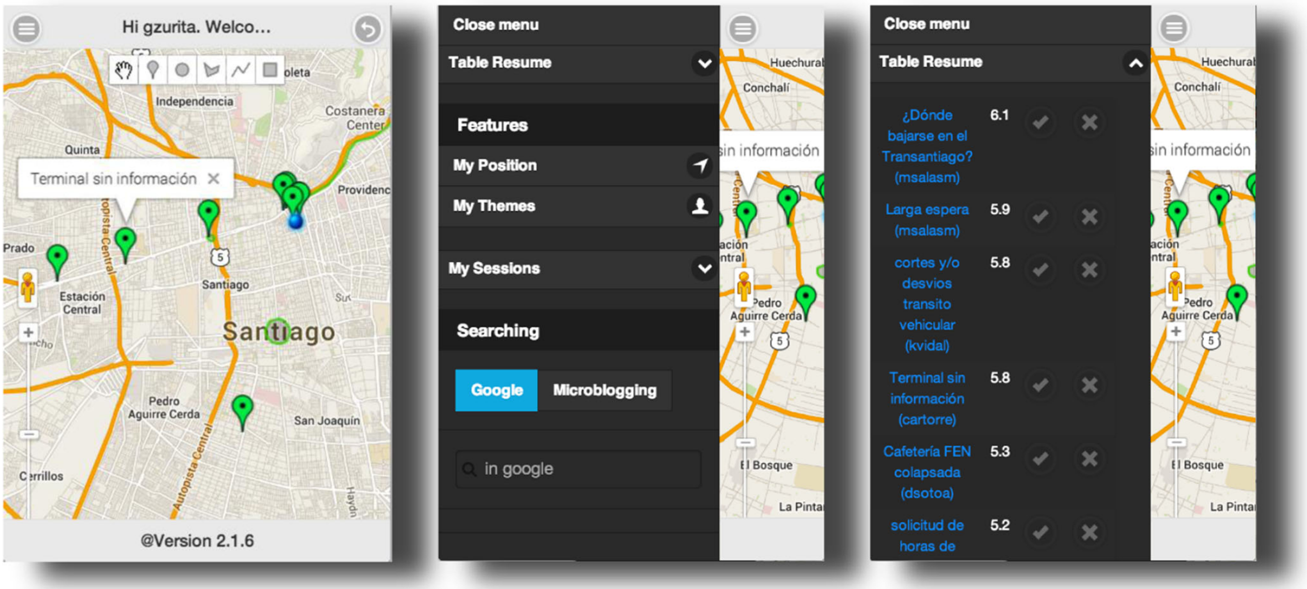

Fig. 7 Three different screenshots from the mobile interface of the geo-collaborative application. The *left* one shows the view for geo-referencing information on the map. The screenshot at the *center* shows the searching tools. The screenshot at the *right* shows the list of all proposals ordered according to their ranking from high to low. This list also identifies proposals that have already been visited or ranked by the user

"expand" and "collapse". Most recent comments are shown above the older ones to support the discussion during divergence and convergence phases of a decision-making process.

(3) Make choices in a convergent mode. In order to fulfill requirement S4, about allowing students to argue for or against the proposal, a rating mechanism was implemented which can be seen at the right screenshot of Fig. 7. The average of the votes is shown aside the title of the proposal. Additionally, marks on the map showing the location of the proposed ideas are displayed in two different colors according to the ratings they received: *Green*, for ideas with an average rate equal or higher than four and *red*, for an average lower than four. In order to comply with design requirement S9, ideas can be commented on and/or rated as soon as they are made public. Also, each comment or idea cannot be deleted or modified according to requirement S6.

Regarding the implementation of the system, it can be described as an integration of various types of cloud services into a single one. In fact, it makes use of functionalities provided by Google Maps and other computing services available in the web, and complements them, implementing the missing functionalities. Some of the main advantages that authors have mentioned about using Cloud Computing are scalability, ubiquity, and reliability. These characteristics match the requirements of many learning scenarios, especially those in which students have to perform learning activities across various settings, in and outside of the classroom, collaboratively and individually working on generating and analyzing data, using different kinds of computing devices supporting this work.

5.2 Evaluation of the geo-collaborative application and results

The geo-collaborative application described in Section 5.1 was evaluated under the same conditions regarding the educational objectives, technical setup, methods for data collecting and its analysis, as the one described in Section 4.1; except that this was evaluated for two semesters in 2013. The sample consisted of 32 and 44 students for the first and second semester respectively; 14 and 24 male for the first and second semester; average age 23.5 and 23.8 for the first and second semester respectively, taking the same undergraduate course on Information Technology for Business, in the ninth semester of an Accounting program, at the Economics and Business Faculty of the Universidad de Chile.

Results obtained (see Table 5), were compared with the mean average obtained for the 4 semesters when Google Maps was used "as it is" for the positive and negative comments associated with questions Q1, Q2 and Q3 in order to find out if students perceived the improvements introduced to minimize the drawbacks. Additionally we registered other qualitative aspects related to geo-collaboration support and usage of microblogging that we will show later.

Comparing the results obtained when using Google Maps "as it is" for four semesters (Avg4 in Table 5), against results obtained when using the geo-collaborative application especially developed for this activity during the next two semesters

Table 5 Qualitative coding of students answers to the questionnaire and the frequency they were mentioned associated with Q1, Q2 and Q3. Y/S=Year/Semester. S1=Semester 1. S2=Semester 2. Avg 4= Average of 4 semesters (S2, S1 of 2011; S2, S1 of 2012). Avg 2= Average of 2 semesters (S2, S1 of 2013)

Positive comments					Negative comments				
		Y/S					Y/S		
		2013					2013		
Avg4	Avg2	S2	S1		Avg4	Avg2	S2	S1	
Q1: Did you experience information overload during the task?									
1.8	5	6	4	Everyone was available on the computer screen.	16.8	3.5	3	4	Too many ideas and comments shown at the same time.
2	6	7	5	Work was performed orderly.	6.5	0	0	0	Some contributions were duplicated.
5	7.5	10	5	History of ideas was easy to follow.	10.5	3.5	2	5	Considerable flow of ideas and feedback.
					9.3	0	0	0	Relation between ideas and comments difficult to establish.
					11.5	0	0	0	Related ideas are shown apart from each other.
					4.8	2.5	2	3	Too many objects shown in the same window at the same time.
					7.3	2.5	3	2	Some comments were simply forgotten.
Q2: How easy was the software itself to use?									
8.3	10	8	12	Easy to understand (Google Maps use).	6.5	1	0	2	Proximate comments are difficult to discern.
2.3	6	7	5	Immediate visualization of new comments.	7.3	0	0	0	Cannot see who deleted comments.
3.5	17	14	20	Reference of ideas in geographical context.	11	0	0	0	Lacks coordination support.
1.3	4	2	6	Use of colors.	10.5	0	0	0	Mapping and chatting unrelated.
3.5	14.5	13	16	Use of text and pictures.	1.3	3.5	3	4	Slow.
1.8	4.5	5	4	Use of icons.	6.3	0	0	0	No private working space.
1.5	9.5	9	10	Easy access to ideas.	9.3	0.5	0	1	Had to improvise in order to collaborate.
0.8	10	8	12	Searching.	8.5	1	0	2	Difficult to merge comments, ideas.
					8	0	0	0	Communication is not primary focus.
Q3: How easy to use was the collaboration support?									
3.8	15.5	13	18	Shared view of ideas.	12.8	1	0	2	Group had to develop alternatives for coordinating group work.
1.3	11	13	9	Eases problem understanding.	11.5	0	0	0	Users can edit others' contributions.
0.8	4.5	5	4	Facilitates view of task progress.	8.3	1.5	0	3	Tool inadequate for discussion support.
1.8	15	11	19	Permits asynchronous interaction.	4.8	2	3	1	Difficult to converge.
1.0	6.5	7	4	Eases time management.	8.5	1	0	2	Asymmetric participation.
0.5	3.5	3	4	Uses colors.	2.5	0.5	1	1	Lack of chat tool.
					7.3	1	0	2	Lacks awareness mechanisms.

(Avg2 in Table 5) we can state that the mean values for the frequency of positive comments is higher for the new application. Also the mean values for the frequency of the negative comments is lower, and in some cases nonexistent. Table 4 shows that for the majority of the negative aspects associated with Q2, the number of negative comments is zero or close to zero. Also the mean values for the frequencies of the negative comments associated with questions Q1 and Q3 of the new application are lower, and the positive comments doubled in the new application for those given for the use Google Maps. Therefore, we do not expect any negative aspects like duplicate contributions, idea proposals separated from the associated commands for ranking and comments, deletion of ideas or comments by other students, lack of private workspaces, and improvisation for supporting the decision-making process.

As we expected, the results obtained show that the new application performs better than Google Maps in supporting the learning activity that was not very difficult to achieve since Google Maps was not designed for that. A more interesting result is that the new application does tackle the shortcoming of Google Maps combined with other "off the shelf" software. This is because its design requirements were mainly extracted through an analysis of the use of Google Maps. Although the first setting (Google Maps with other existing software) was used and tested two times more than the new application, results are still valuable because they show a clear tendency in favor of the new application.

We considered the usability of the new application an important aspect to evaluate since it will impact its acceptance and use in the long term. The most important aspects to be evaluated are the geo-referencing and microblogging mechanisms, since these were the most negative in the first setting. Therefore, for this new application we included five additional questions the students had to answer after they completed the learning activity. These are: Q4: "The geo-collaborative application helped to easily identify problems and solutions in the real context where they occur", which had to be answered with "I strongly disagree"; "I disagree", "I neither agree nor disagree", "I agree" or "I strongly agree" (a Likert scale with 5 levels). Q5: "I geo-localized the information at", which had to be answered with "The same place where I geo-localized it", "Remotely, without having visited the place", or "Remotely, after having visited the place". Q6: "The text introduced by my classmates allowed me to clearly understand the problem", Q7: "The way to introduce/view comments and discussion of the proposals was clear enough" and Q8: "The way I had to input and follow the discussion was uncomfortable", which also had to be answered like Q4. Table 6 shows the mean values for the frequencies obtained for questions Q4 and Q5 that are related to the way students georeferenced their proposals. Questions Q6, Q7 and Q8 are related to the suitability of the microblogging structure of the discussion for supporting the exchange of information necessary to present, comment, discuss and select the best proposals. These questions were applied through a questionnaire to all students that used the new application during the two semesters of 2013. In Q5 students had to report on the most used way to geo-reference their proposals: a) at the same place in real time, using a mobile device, b) remotely, asynchronously, after visiting the place and taking note and/or pictures, or c) remotely, without having visited the place. Additionally, students were asked to write their comments about other aspects of the application, which were not covered by the questionnaire.

Looking at the results we can conclude that the application allowed students to geo-reference their proposals in a proper way, since 58 students agreed or strongly agreed with the sentence "*The geo-collaborative application helped to easily identify problems and solutions in the real context where they occur*". Fifteen neither agreed nor disagreed and only 3 disagreed or strongly disagreed.

Regarding the way the application was used to geo-reference a proposal, there were only 25 that did it at the same place in real time, 14 georeferenced the proposal and wrote its title in the same place, but completed it afterwards remotely and 37 did it in a completely remote manner. From our perspective, the application failed to promote instances of situated learning. Upon analyzing the answers to the open question, we can partly explain that this was due to some students not having had a Smartphone or a tablet, or in the case that they did, they had no Internet access. Many of the students who

Table 6 Answers to the questions associated with the use of geo-localization (Q4, Q5) and the microblogging mechanisms (Q6, Q7 y Q8) implemented by the new application according to the answers of the students from first semester (S1) and second semester (S2) of the year 2013. N=Size of the sample

Q4: The geo-collaborative application helped to easily identify problems and solutions in the real context where they occur						
N	Semester	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
32	S1	0	1	6	22	3
44	S2	0	2	9	29	4
Q5: I geo-localized the information at						
N	Semester	The same place where I geo-localized it	Remotely, without having visited the place	Remotely, after having visited the place		
32	S1	10	17	5		
44	S2	15	20	9		
Q6: The text introduced by my classmates allowed me to clearly understand the problem						
N	Semester	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
32	S1	0	2	5	17	8
44	S2	0	3	4	31	6
Q7: The way to introduce/view comments and discussion of the proposals was clear enough						
N	Semester	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
32	S1	0	0	3	22	7
44	S2	0	0	1	34	9
Q8: The way I had to input and follow the discussion was uncomfortable						
N	Semester	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
32	S1	11	19	2	0	0
44	S2	15	16	3	0	0

declared that they georeferenced the proposal in the site but completed it remotely afterwards said that they did this because it was easier to input text and select the proper photos on a desktop computer and later, have time to analyze and reflect on their findings. The mean number of characters used to describe a proposal was 360, which explains the difficulty of doing this in real time, on a smartphone or tablet.

Results obtained for Q6 let us know that the microblogging-type structure for discussing the proposals was well accepted by the students since only 5 students from a total of 76 disagreed on the suitability of this mechanism.

Regarding Q7 we can say that most students agreed that the comments and discussions of the proposals were clear enough, which leads us to conclude that the microblogging structure of the communication mechanisms offered by the new application satisfy the virtual communication needs the students require to collaboratively discuss and make decisions about the proposals. The space available to input comments and discussion (not to describe them) was 140, which images the structure of the messages of the most popular microblogging site – Twitter. However, they could enter longer messages if desired. The mean number of characters for the messages was 220.

Finally, question Q8 was to validate Q7 since it addressed the same idea, but was expressed in a negative way. For this question we obtained results that are consistent with those obtained for Q7.

6 Conclusions

From the literature review we learned that on the one hand, microblogging has been successfully used to support collaborative learning activities in which discussion among participants plays an important role. On the other hand, we have also found that geo-localization and geo-visualization can be used to implement interesting applications supporting collaborative learning based on the Situated Learning theory. Inspired by these findings, we have seen an opportunity to design a learning activity combining both, microblogging and geo-collaboration, to help students from a business faculty to acquire soft skills such as collaborative decision making, collaboration, discussion, problem solving, etc., supported by information technologies.

In the beginning, our approach was to use only the available free software on the web and standard software like text editors and/or spread sheets. However, we soon observed that using these applications independently of one another, students had serious problems regarding information overload, usability (ease of use), and lack of proper collaboration support. To clearly identify the problems we conducted a formal and systematic study with the students. This study allowed us to derive some important requirements for designing a more suitable application to support the learning activity. We also derived some additional, general functional requirements from the literature about decision making like: (1) supporting information gathering and brainstorming in a divergent mode is required in a first stage. (2) Support for finding alternatives, information processing and commenting the proposed alternatives was necessary at a second stage. And (3) support for making choices in a convergent mode was necessary in a third stage, for which we added the microblogging-type communication services.

After defining the design requirements we built a new geo-collaborative application that includes geo-referencing and microblogging to support the learning activity. After two semesters evaluating the new application, we obtained positive results compared them with results obtained from the previous scenario supported by Goggle Maps and software “off the shelf”.

The evaluations applied to the learning activities carried out were performed to test the usability of the technical scaffolding development and not its utility. Learning achievement, motivation, quality of the proposals and their solutions are not in the scope of this article and will be matters for future work. According to our understanding, the results of this article should be regarded separately from the research aimed at evaluating the learning outcomes. This work possesses more of an exploratory character since we wanted to first obtain information necessary to develop suitable technological scaffolding for the learning activity that will allow for measuring the quality and benefits of applying the new application.

The main contributions of this work are the following: first, we conceived a learning activity and a supporting application that allows students to train their skills in identifying and understanding IT developments and knowing how to apply them to business management in organizations, as specified by the International Association to Advance Collegiate Schools of Business AACSB (AACSB 2014). This activity also allows students to develop some soft skills, like collaborative decision making, by proposing ideas, discussing them and choosing the best ones collaboratively. According to the literature, this approach (combining microblogging with geo-collaboration) has not been implemented yet. Second, we present a procedure for designing a geo-collaborative application based on first observing how users perform with existing applications that meet some of the requirements and, according to this observation, we derive which functionality is missing or can be improved. Results from evaluations tend to confirm that we developed and an effective tool for supporting this particular learning activity.

An additional contribution of this work is to present an example of the use of software available on the web (by using Google Maps services) for different learning styles as reported in the literature. Instead of using services as they are offered, we propose combining them in a new application that can be tailored to meet the requirement of a specific learning activity, taking advantage of the characteristics of cloud computing for learning (Mousannif et al. 2013) and getting rid of at least some of its draw backs and hopefully not introducing new ones. Technical details on how to easily implement applications in this way can be seen in (Zurita et al. 2014).

Finally, we think that the geo-collaborative application presented here can also be used in organizations as a tool for supporting the identification of new business opportunities, products or services based on IT use.

References

AACSB. (2014). Association to Advance Collegiate Schools of Business http://www.aacsb.edu/.

Altamirano, E., Nava, A., & Mojica, R. A. (2009). Microblogging en la Educación. *Revista Digital Alternativa, 6*(20), 33–41.

Antunes, P., Sapateiro, C., Zurita, G., & Baloian, N. (2010). Integrating spatial data and decision models in an e-planning tool. In Collaboration and Technology (pp. 97–112). Springer Berlin Heidelberg.

Antunes, P., Ferreira, A., Zurita, G., & Baloian, N. (2011). Analyzing the support for large group collaborations using Google maps. In Computer Supported Cooperative Work in Design (CSCWD), 2011 15th International Conference on (pp. 748–755). IEEE.

Benford, S. (2005). Future location-based experiences. JISC Technology and Standards Watch. Available at: http://www.jisc.ac.uk/techwatch.

Borau, K., Ullrich, C., Feng, J., & Shen, R. (2009). Microblogging for language learning: Using Twitter to train communicative and cultural competence. Advances in Web Based Learning–ICWL, 78–87.

Briggs, R., Vreede, G., & Nunamaker, J. (2003). Collaboration Engineering with ThinkLets to Pursue Sustained Success with Group Support Systems. *Journal of Management Information Systems, 19*(4), 31–64.

Brown, J., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher, 18*, 32–42.

Cai, G. (2001). Extending Distributed GIS to Support Geo-Collaborative Crisis Management. *Progress in Human Geography, 11*(1), 4–14.

Capata, A., Marella, A., & Russo, R. (2008). *A geo-based application for the management of mobile actors during crisis situations*. Washington: Proceedings of the 5th International ISCRAM Conference.

Chen, Y., Kao, T., Sheu, J., & Chiang, C. (2002). A mobile scaffolding-aid-based bird -watching learning system. Paper presented at the Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education.

Convertino, G., Zhao, D., Ganoe, C., Carroll, J., & Rosson, M. (2007). A Role-Based Multiple View Approach to Distributed Geo-Collaboration. *Lecture Notes in Computer Science, 4553*, 561–570.

Dede, C. (2010). Comparing frameworks for 21st century skills. 21st century skills: rethinking how students learn, 20, 51–76.

Driskell, J. E., & Salas, E. (2006). *Groupware, group dynamics, and team performance*. Washington, DC: American Psychological Association.

Drummond, A. (2010). *Situated Learning and Assessment*. Wiscounsin: Teaching and Learning Symposium UCD School of Public Health, Physiotherapy and Population Science.

Dunlap, J. C., & Lowenthal, P. R. (2009). Tweeting the night away: Using Twitter to enhance social presence. *Journal of Information Systems Education, 20*(2), 129–135.

Ebner, M., Lienhardt, C., Rohs, M., & Meyer, I. (2009). Microblogs in Higher Education-A chance to facilitate informal and process-oriented learning? *Computers & Education, 55*(1), 92–100.

Fonte, C. C., Bastin, L., See, L., Foody, G., & Lupia, F. (2015). Usability of VGI for validation of land cover maps. To appear in International Journal of Geographical Information Science.

Griffin, P., McGaw, B., & Care, E. (2012). *Assessment and teaching of 21st century skills*. Dordrecht: Springer.

Grosseck, G. (2009). To use or not to use web 2.0 in higher education? *Procedia-Social and Behavioral Sciences, 1*(1), 478–482.

Grosseck, G., & Holotesku, C. (2008). *Can we use Twitter for educational activities*. Bucharest: 4th international scientific conference, eLearning and software for education.

Hill, T. R., & Roldan, M. (2005). Toward third generation threaded discussions for mobile learning: opportunities and challenges for ubiquitous collaborative environments. *Information Systems Frontiers, 7*(1), 55–70.

Holotescu, C., & Grosseck, G. (2010). 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" (eLSE) (No. 01, pp. 365–374).

Holtzblatt, K., Wendell, J. B., & Wood, S. (2004). Rapid contextual design: a how-to guide to key techniques for user-centered design. Elsevier.

Java, A., Song, X., Finin, T., & Tseng, B. (2007, August). Why we twitter: understanding microblogging usage and communities. In Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis (pp. 56–65). ACM.

Junco, R., Heiberger, G., & Loken, E. (2011). The effect of Twitter on college student engagement and grades. *Journal of Computer Assisted Learning, 27*(2), 119–132.

Kaner, S. (1996). *Facilitator's guide to participatory decision-making*. Philadelphia: New Society Publishers.

Lave, J. (1993). *The Practice of Learning* (In S. Chaiklin, and Lave, J. (Ed.), Practice: Perspectives on Activity and Context). Cambridge: Cambridge University Press.

Lave, J., & Wenger, E. (1990). Situated learning: legitimate periperal participation. Cambridge, UK.

Lin, Y. T., Huang, Y. M., & Tan, Q. (2010). Location-based and knowledge-oriented microblogging for mobile learning–framework, architecture, and system. In Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE), 2010 6th IEEE International Conference on (pp. 146–150). IEEE.

Lorna, U. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation, 1*(1), 81–102.

Luo, T., & Gao, F. (2012). Enhancing classroom learning experience by providing structures to microblogging-based activities. *Journal of Information Technology Education: Innovations in Practice, 11*(1), 199–211.

MacEachren, A. M., & Kraak, M.-J. (2001). Research challenges in geovisualization. *Cartography and Geographic Information Science, 28*(1), 3–12.

MacEachren, A., Brewer, I., Cai, G., & Chen, J. (2003). *Visually enabled geocollaboration to support data exploration and decision-making* (pp. 10–16). Durban: Proceedings of the 21st International Cartographic Conference.

MacEachren, A., Cai, G., Sharma, R., Rauschert, I., Brewer, I., Bolelli, L., & Wang, H. (2005). Enabling Collaborative Geoinformation Access and Decision Making through a Natural, Mulimodal Interface. *International Journal of Geographical Information Science, 19*, 293–317.

MacEachren, A., Guoray, C., Brewer, I., & Chen, J. (2006). Supporting Map-Based Geocollaboration through Natural Interfaces to Large-Screen Displays. *Cartographic Perspectives, 54*, 4–22.

Miles, M., & Huberman, A. (1994). Qualitative data analysis. Thousand Oaks, California: SAGE. Quacquarelli, N., Cambridge, M.A.

Mousannif, H., Khalil, I., & Kotsis, G. (2013). Collaborative Learning In the Clouds. *Information Systems Frontiers, 15*(2), 159–165.

Richards, D. (2015). Testing the waters: local users, sea level rise, and the productive usability of interactive geovisualizations. Communication Design Quarterly, pp 20.

Robinson, A. C., Chen, J., Lengerich, E. J., Meyer, H. G., & MacEachren, A. M. (2005). Combining usability techniques to design geovisualization tools for epidemiology. *Cartography and Geographic Information Science, 32*(4), 243–255.

Schafer, W., Ganoe, G., & Carroll, J. (2007). Supporting Community Emergency Management Planning through a Geocollaboration Software Architecture. *Computer Supported Cooperative Work, 16*(4–5), 501–537.

Shum, S. B., Cannavacciuolo, L., De Liddo, A., Iandoli, L., & Quinto, I. (2011). Using Social Network Analysis to Support Collective Decision-Making Process. *International Journal of Decision Support System Technology (IJDSST), 3*(2), 15–31.

Silva, M. J., Gomes, C., Brigas, C., Marcelino, M., Gouveia, C., & Ydreams, C. (2008). Children as authors of georeferenced multisensory information: towards the design of simulation and editing tools for an educational context. *Proceedings of the ED-MEDIA, 2008*, 1578–1586.

Silva, M. J., Gomes, C. A., Pestana, B., Lopes, J. C., Marcelino, M. J., Gouveia, C., & Fonseca, A. (2009). *Adding space and senses to mobile world exploration*. Boston: Morgan Kaufmann.

Slocum, T., Cliburn, D., Feddema, J., & Miller, J. (2003). Evaluating the usability of a tool for visualizing the uncertainty of the future global water balance. *Cartography and Geographic Information Science, 30*(4), 299–317.

Srivastava, S. K., & Tait, C. (2012). An activity-based learning approach for key geographical information systems (GIS) concepts. *Journal of Geography in Higher Education, 36*(4), 527–545.

Stepanyan, K., Borau, K., & Ullrich, C. (2010, July). A social network analysis perspective on student interaction within the Twitter microblogging environment. In Advanced Learning Technologies (ICALT), 2010 I.E. 10th International Conference on (pp. 70–72). IEEE.

Turban, E., Liang, T., & Wu, S. (2011). A framework for adopting collaboration 2.0 tools for virtual group decision making. *Group Decision and Negotiation, 20*(2), 137–154.

Van der Lelie, C. (2006). The value of storyboards in the product design process. *Personal and Ubiquitous Computing, 10*(2–3), 159–162.

Vygotsky, L. (1994). The Development of Academic Concepts in School Aged Children. In R. Veer & J. Valsiner (Eds.), *The Vygotsky reader* (pp. 335–370). Oxford: Blackwell.

Wong, S. (1994). Preference-based decision making for cooperative knowledge-based systems. *ACM Transactions on Information Systems, 12*(4), 407–435.

Zhao, D., & Rosson, M.B. (2009, May). How and why people Twitter: the role that micro-blogging plays in informal communication at work. In Proceedings of the ACM 2009 international conference on Supporting group work (pp. 243–252). ACM.

Zurita, G., & Baloian, N. (2010, April). Collaborative geo-referenced knowledge creation for designing and planning. In Computer Supported Cooperative Work in Design (CSCWD), 2010 14th International Conference on, Shanghai, China, (pp. 257–262). IEEE.

Zurita, G., & Baloian, N. (2012). Context, patterns and geo-collaboration to support situated learning. Ubiquitous Computing and Ambient Intelligence (pp. 503–511): Springer.

Zurita, G., Baloian, N., & Frez, J. (2014). Using the cloud to develop applications supporting geo-collaborative situated learning. *Future Generation Computer Systems, 34*, 124–137.

Nelson Baloian graduated as Computer Engineering from the Universidad de Chile in the year 1987. He obtained his PhD. from the University of Duisburg, Germany in the year 1997. His main research subject has been Computer Supported Learning and Distributed Systems, being author of more than 25 journal publications related on these subjects and 80 peer reviewed conference. He has been visiting professor at the universities of Waseda, Japan, and Duisburg-Essen, Germany He is currently Associate Professor at the Department of Computer Science of the Universidad de Chile in Santiago, Chile.

Dr. Gustavo Zurita received his Ph.D. in Civil Engineering, with Computer Science major, from Catholic University of Chile. Currently he is an Associate Professor at the Department of Management Control and Information Systems of the Faculty of Economics and Business 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 more than 20 ISI-indexed journal articles. Some of his journal articles are among the most cited ones in mobile computer supported learning in the world.