PROPOSED RESEARCH

1. THE PROBLEM AND ITS RELEVANCE

In today’s world, students completing their compulsory grade schooling are confronted by an array of demanding environments requiring that they carry out ever more complex tasks [17]. To meet this challenge, young people must develop skills in effective communication, teamwork and solving real problems through critical and analytical thinking [18] that are both supported and mediated by information and communication technologies (ICTs), which in turn require skills beyond mere functional or technical ones, [1]. In the face of this reality, interest is growing among teachers, researchers and politicians in the development of a set of proposals [19-21] known as “21st Century Skills” defining the implementation and evaluation of skills students will need in order to respond to the demands of today’s environment, [1]. The OECD’s New Millennium Learners project has suggested that governments should “make an effort to properly identify and conceptualise the set of skills and competencies required so as to incorporate them into the educational standards that every student should be able reach by the end of compulsory schooling”, [1]. In Chile, two organizations – the Enlaces centre for education and technology [22] and CEPPE [23]– have together defined a set of skills for learning using ICTs which school students must develop under the title of “21st Century ICT Skills” [2]. In 2009, these two organizations conducted a pilot study on the existing levels of these skills among 10th grade students. The results indicated that although “50% of the students correctly answered between 13 and 24 questions out of a total of 48”, their mastery of these skills is in fact only partial given that as the cognitive complexity of the tasks increased, the percentage of students who completed them correctly decreased”, [2, 5]. Moreover, in 2011 and 2013, the Chilean Ministry of Education applied student surveys called SIMCE TIC in order to measure the three aspects defined by the “21st Century ICT Skills”, which resulted in a highly deficient outcome, both for 2011 [6], and 2013 [7]. Given this need, and in light of the following: 1) ICTs in education are strongly associated with mobile devices [8, 9], which bring the acquisition of knowledge to any place and context and offer the ability to search, select, organize, generate new information and knowledge, share, reuse, transmit, collaborate and interact [9, 16, 24] with content while students are in motion; 2) the recent interest in research on the use of microblogging through mobile devices to support learning, which extends and promotes personal social interaction between students to and within educational contexts [16, 25, 26]; and 3) the growing interest in using geocollaboration services to contextualize learning in actual places of use [14, 27, 28]. The intention of this research project proposal is to demonstrate the feasibility of developing “21st Century ICT Skills” simultaneously with curriculum specific learning content for Chilean high school students through the use of mobile devices with microblogging and geocollaboration services in and outside the classroom. With this purpose in mind, the project will develop a software toolkit in HTML5 in order to implement and validate the design of two collaborative applications for mobile devices that will allow students cursing the 9th and 10th grades to acquire these said skills via the accomplishment of a series of fundamental objectives set for their grade levels (see section 4 for more details). One of the applications is aimed at the “Language and Communication” (hereinafter, LC) learning area and uses microblogging while the other is conceived for use in the “History, Geography and Social Sciences” (hereinafter, HGSS) area in real contexts located in concrete physical spaces using microblogging and geocollaboration functionalities. As outcomes we expect that microblogging and geocollaboration services will provide new mechanisms and ways to achieve learning goals and incorporate new interaction contexts that can support a range of pedagogical practices [16] as the students develop their “21st Century ICT skills” for learning simultaneously. The aim is that the ICTs will not simply be mastered in the strictly functional or technical sense but will be employed as a means of learning. The collaborative applications and educational practices designed during the project and the results of their implementation and evaluation will also lay the basis for a proposed taxonomy and guidelines for addressing the development of the “21st Century ICT Skills” in students simultaneously with specific curriculum content learning through the use of mobile devices with microblogging and geocollaboration services in and out of the classroom.

2. THEORETICAL FUNDAMENTALS AND LITERATURE REVIEW

The following sub-sections present the theoretical background. Section 2.1 analyzes the importance of the “21st Century Skills,” whose incorporation into the various areas of school curriculum content is called for by both national and international actions and initiatives; and how these have been particularly introduced in Chile (section 2.1.1), as well as the low results obtained by some evaluations performed during 2009, 2011 and 2013 which concern the Education Ministry of the Chilean state, (section 2.1.2). Section 2.2 examines the use of mobile devices in the education field and aspects of their design and evaluation (section 2.3). The current state of the art in research on microblogging services as a support for learning is analyzed in section 2.2.1, and the same is done for geocollaboration services in section 2.2.2. These analyses demonstrate the potential added value of the ICTs for supporting student learning in different contexts and circumstances, and justify the novel aspects to be developed in our research proposal (section 3).

2.1 OECD “21st Century Skills”

The rapid development of ICTs and their impact on people’s life style, working and learning has prompted the drafting of various proposals for “21st Century Skills”, [29]. According to the OECD [1], the goal is to identify and incorporate the skills required to use ICTs as support for the learning process with curriculum content at various grade levels. The aim is to support students to go beyond the mere manipulation and operation of these technologies and apply them to take full advantage of the enormous quantity of information that can be accessed today [4].

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According to [1, 3, 4], the following skills are common to all proposals endorsing ICT skills for learning that combine cognitive and higher order activities with functional skills for the use and management of ICTs (no matter what type they are), of them: collaboration, communication, ICT literacy, social/cultural skills (citizenship), creativity, critical thinking, problem solving, productivity and self-direction. In [3], differences between the proposals were limited to variations in the degree of importance they attached to individual skills and the way these were grouped or categorized is established.

2.1.1 "21st Century Skills" in the Chilean context: "21st Century ICT Skills"

In Chile, the government has been working through Enlaces ([5]) since 1992 to contribute to and promote the broadening of access to the new ICTs by teachers, students and the education community. However, although ICTs have been officially integrated into the secondary school curriculum since 1998 and the primary school curriculum since 2008 as an interdisciplinary subject covering tasks and activities that cut across the new study programs adopted at both levels, the focus is confined to functional skills for the proper use and handling of ICTs rather than in developing skills for learning by combining the purely functional ones with cognitive and higher order activities, [2]. As late as 2009 some ICTs skills for learning were introduced into certain Chilean curricula [5] as part of the fundamental cross-curricular objectives. Also in 2009, Enlaces [5], CEPE [6] and MIDE UC [30] published the “21st Century ICT Skills” proposal [2] based on a classification suggested by the OECD [1] which defines three dimensions: information, communication, and ethics and social impact. Each in turn has two sub-dimensions, and a set of ICT skills (see the first three columns of Table 1 in section 4). Some of these skills were not included in the original “21st Century ICT Skills” proposal (shown in cursive in third column of Table 1) but have been added from the “21st Century Skills” [20], to the present project due to their relevance and the feasibility of using them together with concrete curriculum content supported by mobile devices (see Novel Aspect 1 in section 3).

2.1.2 Results of the “21st Century ICT Skills” and the first SIMCE ICT 2011 in the Chilean context

In October and November of 2009, an evaluation instrument was used to measure ICT skills for learning in a pilot study commissioned by Enlaces to identify the level of development in students of the “21st Century ICT Skills”, [2]. A total of 1,185 10th grade students participated. The study used an application that included a desktop computer, an e-mail manager, a web browser, text processors, spread-sheets and a presentation program (mobile devices were not considered, in spite of the increasing penetration rate in the high school contexts). The students were assigned tasks corresponding to each of the “21st Century ICT Skills” dimensions and sub-dimensions of Table 1. The results indicated that although the students were able to perform tasks demanding ICT functional skills, the majority of them were unable to handle those entailing greater cognitive complexity requiring abilities included in the “21st Century ICT Skills”. According to [2], “students were able to solve somewhat less than half the tasks in the test. In terms of skills, on the one hand it was found that the majority of students were able to solve tasks related to the use of information as consumers, that is, approximately three quarters of the students could search for information and half of them could also organize and manage digital information. On the other hand, very few students were able to succeed in tasks related to the use of information as producers, that is, only one third of the students could develop their own ideas in a digital environment and less than one fifth could refine digital information and create a representation in a digital environment”. Moreover in 2011 and 2013 the Chilean Ministry of Education applied the SIMCE TIC test to 10,321 and 11.185 students respectively each year, to the 10th grade school year across 505 schools [6] for 2011, and 492 schools for 2013 [7], in order to measure the abilities for using ICT inside the classroom along with the ability and solve problems of high cognitive complexity, interact with others and behaving ethically inside the frame of the legal regulation. Results indicated that 46.2% for 2011, and 46.9% for 2013 of the students show a basic level of achievement; 50.5% (2011) and 51.3% (2013) an intermediate level; and only a 3.3% for 2011 and 1.8% for 2013 achieved an advanced level. Students from the poorest quintile of the school system, the results are even worse. This measured skills are not technology-driven, as they do not refer to the use of any particular software, [2]; therefore in our understanding, if students had used mobile devices, the results would be similar. The Education Minister of 2011 stated, “These results do not satisfy us. We know many young people make use of technology but we need to know how they use it for learning” [31], and the Education Minister of 2013 indicated that “the main challenge is how to develop better advanced skills in more students” [32]. These findings reveal that the development of “21st Century ICT Skills” in the Chilean educational system is still a major challenge, one whose incorporation into curriculum content and learning areas at the compulsory levels of the Chilean school system is of utmost importance.

2.2 Mobile Devices and Learning: Mobile learning

Nowadays, mobile devices have become broadly available, opening an additional platform for supporting learning [8, 9]. According to [9], context is the basis on which the value of mobile devices to learning is based, which allows support of knowledge access during the social interaction between students and teachers, in diverse authentic situations, different conditions of space and time, and while they are moving inside and outside the classroom; showing diverse relevant benefits to learning conditions of space and time, and while they are moving inside and outside the classroom; showing diverse relevant benefits to learning [24, 33-36]. The main characteristics of mobile learning are [8, 37]: a) available, anywhere, to enable communications with teachers, experts and peers; b) adaptable, to the context of learning and the learner’s evolving skills and knowledge; c) interactivity, learners can interact with teachers or peers using synchronous or asynchronous communication; and d) seamless integration of the learning experiences across various dimensions including formal and informal learning contexts, individual and social learning, and physical world and cyberspace, [10]. Researchers in [38], propose a classification of activities on main theories relevant to learning with mobile devices: a) behaviorist, activities that promote learning as a change in observable actions, b) constructivist, activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge, c) situated, activities that promote learning within an authentic context, and d) collaborative, activities that promote learning through social
interaction. Authors such as [13, 16, 25, 39, 40] have complemented the educational use of mobile devices, with activities that involve the use of microblogging as a new way to integrate and/or extend social interaction from personal to educational contexts [8, 11]. According to [41, 42], microblogging offers students the opportunity to expand their personal networks and also collaborate and learn within those networks. Likewise, several researchers [43-53] have complemented the use of mobile devices with geocollaborative learning activities. According to [42, 54], mobile devices, combined with content access virtually anywhere and anytime, allow learners to gain new learning experience in a variety of situations, not only inside the classroom: environments of situated learning [42, 55]. The situated learning environments offer new possibilities of bringing computer support into the learning context and present a challenge to the integration of mobile context-aware and location computing in these new educational settings.

2.2.1 Benefits of microblogs with mobile devices in learning contexts

A microblog is a popular service of social networks where users can post and share information, by writing short messages by using mobile devices or desktop computers [56]. Researches reporting on the use of Twitter (the most popular microblog), show that it is used to communicate with others, receive and give information about current news, and to tell activities to others [57]; resulting in 3 categories of users: producers of information (the minority), friends, and information seekers. According to [58-62], the use of microblogs has been on the rise in personal and educational contexts as they can be accessed at anytime and anywhere. Recent research has identified some benefits and disadvantages associated with the use of microblogging, which are:

**Benefits:**

a) According to [37], 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. 
b) Students get feedback on their comments [26, 63], feeling motivated to keep virtual and face-to-face discussions [26, 64] with their classmates, get valuable information [26, 65], keep informed on what happens in their courses in a funny way [63, 65], and develop competencies to transmit relevant and summarized information, [65].
c) Has a positive influence in the process of argumentation and discussion [65]; favors students reflection processes [26, 65]; supports collaboration [63, 66], creativity [63], critical thinking, development of communication skills [63, 66], productivity [67] and self direction [63, 66].
d) Encourages the construction of communities of practice [25, 63, 65-67] 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 [39, 68].
f) Teachers rely on a space for discussion outside the class [68], increasing its dynamics [39, 63], offering direct and immediate feedback to students [26, 39], and favoring the inclusion of students in the real world [65].

**Disadvantages:**

a) Students’ distraction due to the information volume that is not relevant in the educational process, [65].
b) Lack of courtesy in communications, [65].
c) Grammatical errors as there are 140 characters per entry, [37].
d) Teacher not being available to provide feedback to students through the microblog, [65].

Furthermore, we analyze seven recent studies [16, 25, 26, 39, 40, 63, 68], which present nine concrete applications of microblogging in the educational context and not just theoretical analysis. The criteria of selection was to take into account those research works using twitter, or mobile devices, or on works focused on learning inside and outside the classroom. The outcomes of these nine concrete applications are: a) All of them are focused on university students. b) The objective for all of these studies (except [68]) is to promote communication and interaction among students and between student and teacher; 6 applications [16, 25, 26, 63] ([16] includes three applications) show a positive increase in the communication and social interactions of the students, additionally [63] reports positive outcomes in self-learning, creativity and innovation. c) Five works [25, 39, 40, 63, 68] study Twitter usage as microblog. d) Consideration of authentic contexts for learning were addressed in only three studies [25, 39, 40], particularly for learning a foreign language in a real context of communication, without intensive mobility and interaction inside and outside the classroom; and despite 4 applications [16, 25, 39, 40] having 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. f) None of these investigations directly associates competencies and skills similar to the ones proposed by the "21st century ICT Skills" to be developed by students through the use of microblogs. g) No research report about introducing activities with specific curricular contents. And h) there is no formal assessment of the objectives proposed; neither any taxonomy or methodology to model the use of microblogging in supporting learning. Gao et.al. [12], critically analyze 21 studies from 2008 to 2011, establishing that microblogging has a potential to encourage participation, engagement, reflective thinking, problem solving [69], as well as collaborative learning under different learning settings. But, the quality of these research varies greatly, and therefore suggesting a need for rigorous research on this area.

2.2.2 Advantages of Geocollaboration supporting pedagogical learning activities

According to [70] geocollaboration is a complex computer-supported collaborative working situation where people execute diverse tasks by georeferencing data and information by using mobile devices or desktop computers. The task may involve collaborative exploration or mapping meaningful representations [70] and/or interpreting geographically related data [71] making geospatial decisions collaboratively in various situations, like crisis management [72], collaboratively building planning [73], or collaboratively defining strategies [74]. A central issue in geocollaboration is the modeling of collaborative tasks performed by a group of people involving the contextualization, construction and exchange of georeferenced data and information 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.

According to [27], conducting educational activities and collaborative teaching practices by georeferencing information in authentic contexts and physical locations, enables students to establish significant cognitive relationships between what was
understood inside the classroom and what is visualized in a real context. These activities and educational practices are based on the learning theory called Situated Learning. Situated Learning theory states that learning requires theoretical concepts learned inside a classroom to be linked to practical situations in authentic contexts where they can be applied. According to [76, 77], the way humans learn implies practicing the concepts acquired in theory. Vygotsky [77] explains that teaching activities involving conceptual content (learned inside a classroom) and implementation (in real situations) are not only complementary, but also feed back 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 [76]. Georeferencing diverse data and information such as texts, pictures, files, etc. at concrete physical locations where is instantiating the objectives of learning is required; recording the history of routes; taking notes on real geographic zones; determining routes; comparing different notes made in different locations; exploring and reporting collaboratively what is happening in their environment, [64]; personalizing the learning experience [78]; helping to identify technological business, [79]; which introduce an added value to situated learning applications supported by mobile devices [28, 80, 81].

We analyze twelve research works [43-47, 49-53, 64, 82], chosen because they have many of the elements literature says is characteristic of situated learning applications. We can highlight the following: a) All the works were conducted with primary and secondary students, between 10 and 17 years old, except for [44] whose investigation was conducted with those (not students) age 23 and 42. b) Educational activities were are associated to specific objectives: learning a foreign language [44, 49, 50, 53], learning natural sciences [45, 46, 48, 51, 52], and recognition of historic sites [43, 82]. Nevertheless, the outcomes presented do not mention the level of learning accomplished by students, or whether they are aimed at achieving formal educational objectives of some curricula; except for [46]. c) All studies provide results in terms of usability and technical performance of the applications proposed, but does not mention any outcomes on assessment informing about the learning of specific curricular contents, or about the accomplishment of competencies similar to “21st Century ICT Skills”. And d) There is no any taxonomy or guidelines to address the design of geocollaborative applications.

### 2.3 Designing and evaluating Mobile Learning applications

A central task in the design of technology for mobile learning is to promote enriching social interactions and data exchange within and across contexts. This involves understanding how to design technologies, media and interactions to support a seamless flow of learning across contexts, and how to integrate mobile technologies within education to enable innovative practices, [10, 83]. To this end, much can be learned from interaction design research [84], which offers general principles for human-computer interaction on mobile devices. Furthermore, findings from mobile learning research [85] suggest the need to: a) Implement quick and simple interactions. b) Prepare flexible materials that can be accessed across contexts. c) Consider special affordances of mobile devices that might add to the learner experience. And d) Use mobile technology not only to ’deliver’ learning but also to facilitate it, making use of features for voice communication, note-taking, photography, and time management. A design challenge is to enrich the learning conversations and enhance the learner’s experience without interfering with it [86]. One way of achieving this is through a taxonomy and the method for the design of a mobile computer-supported collaborative learning system, [35].

On the other hand, mobile learning applications poses additional challenges to the evaluation of both technology and learning, which require new tools and methods for the collection and analysis of mobile learning data. The challenges are: unpredictability of the context of use, the learning process, the mode of use, and looking beyond the ’wow’ effect [87]. In accordance to [77], the success of a collaborative system depends on multiple factors, including the group characteristics and its dynamic, the individual, social and organizational context in which it is inserted, and the positive and negative effects of technology on the group’s tasks and processes. Therefore, collaborative system evaluation is always necessary to determine the impact a software solution will have on the individuals, groups and the organization. Three evaluation scenarios (role-based, rule-based and knowledge-based), were proposed by [88] jointly with a set of guidelines to select the appropriate evaluation methods to evaluate collaborative systems according to the following parameters: realism, generalization, precision, system detail, system scope and invested time.

### 3. NOVEL ASPECTS TO BE DEVELOPED

On the basis of the theoretical fundamentals and literature review discussed above, this section presents the major novel aspects to be developed in the proposed research project.

**Novel Aspect 1: Simultaneous development of “21st Century ICT Skills” and 9th and 10th grade curriculum content, supported by two collaborative applications running on wirelessly interconnected mobile devices with microblogging services and geocollaboration functionalities for use both in and out of the classroom.**

This is considered to be novel in light of the literature review on the state of the art in the use of microblogging (section 2.2.1) and geocollaboration (section 2.2.2) services in education, which revealed that the learning objectives addressed in existing studies are not integrated within a formal concrete curricular nor do they include the development of the “21st Century ICT Skills” in students. The chosen curricular content belong to the 9th and 10th grade LC and HGSS learning areas (similar level grade, applied in [2]), which will be associated with various expected activities and learning outcomes for curriculum in Chilean secondary grade schooling, jointly with the three dimensions of “21st Century ICT Skills” proposed by the Chilean Ministry of Education, and their respective sub-dimensions. Concrete examples of educational tasks the students would carry out, and some indications of the nature of the collaborative applications proposed are described in section 4.
Novel Aspect 2: Validation of the impact of the educational activities on content learning and progress in developing “21st Century ICT Skills.”

The studies analyzed in the literature survey on the use of mobile devices and microblogs in educational contexts (section 2.2.1) and their use in geocollaborative activities (section 2.2.2) did not contain formal results based on experimental evaluations about the impacts of these mediation mechanisms on specific curriculum content learning. Nor were any studies identified that focussed on acquisition of skills included in the “21st Century ICT Skills”. It would therefore be a genuinely novel contribution to conduct evaluations that determine the effectiveness of ICTs as a means of achieving educational objectives (“21st Century ICT Skills” simultaneously with specific curricula content) rather than simply as ends in themselves, which is the case in some of the studies discussed in sections 2.2.1 and 2.2.2 where results were obtained mainly through usability evaluations in educational contexts, preliminary evaluations or exploratory assessments.

To determine the effects of using mobile devices with microblogging and geocollaboration services on the acquisition of “21st Century ICT Skills” and specific curriculum content, experimental evaluations will be conducted to measure the differences in learning levels between control and experimental groups, with each grade (9th and 10th) and learning area (LC and HGSS) assessed separately. To achieve the aforementioned, the evaluation methods of mobile learning applications to collect and analyze the corresponding data described in section 2.3 will be applied. The design of the experimental study will take place in real situations, where the students will collaboratively use each of the two proposed mobile learning applications in and out of the classroom while they roam the city they live during two or three weeks.

Novel Aspect 3: Development of a taxonomy and a methodology for addressing particular kinds of content, learning tasks and “21st Century ICT Skills”, through mobile devices, and microblogging and geocollaboration services

As was already demonstrated in the analysis of existing studies on the use of mobile devices in educational contexts with microblogs (section 2.2.1) and geocollaborative activities (section 2.2.2), so far no formal or informal taxonomy, neither methodologies have been proposed in the literature that would provide a generalization and conceptualization grounded in aspects of the use of technological support for simultaneously developing "21st Century ICT Skills" and specific curriculum content. Building such taxonomy and methodology is therefore both necessary and relevant. The taxonomy should conceptualize and define the contours, and characteristics of the implemented applications, which support the applications provide for the chosen educational activities in and out of the classroom, what are the relationships between key components (educational contents and ICT skills) that explain the incidence and/or effects of certain aspects of the applications on other aspects, what contribute the mobile devices with microblogging and geocollaboration services can make, etc. Thus, this taxonomy will serve as the conceptual basis for the collaborative applications created during the project and their use for simultaneously developing the “21st Century ICT Skills” and a range of curriculum content when used with microblogging services and geocollaboration functionalities. Assuming a pragmatic approach, this is a project from which we will explore and learn about how to best implement these kinds of novel learning experiences in schools.

The methodology will be developed considering the many aspects that will be developed, conceptualized and implemented, and based on the results obtained through the experimental validations and the taxonomy. This methodology will provide the basis for explaining, developing and building other similar collaborative applications with different fundamental educational objectives for other learning areas and grade levels.

4. EXAMPLES OF THE STUDENTS’ TASKS MEDIATED BY THE COLLABORATIVE APPLICATIONS

The design of the collaborative application using microblogging on mobile devices will promote a highly interaction and communication among students, and between teacher and students at any time and place, and will allow them to incorporate circumstances that arise in their daily lives as a source of learning; including some of the benefits already identified in similar research works and will tackle the drawbacks identified in sections 2.2, 2.1.1 and 2.1.2. Applications using microblogging and geocolaboration, will enable the students to situate themselves in real contexts and incorporate locations in space, images, videos; thus complementing the processes of social interaction, communication and discussion in and outside of the classroom; i.e. situated learning. The collaborative applications should have a robust, reliable and scalable wireless communication technology in order to support 40 or more students plus 1 or 2 teachers simultaneously connected; and should support the exchange of various data such as text, images, tiles of maps under different working configurations. These working configurations could be 6 to 10 working groups, each consisting of 2 to 7 students or all students working together inside a classroom. The design of application interfaces should be simple and following paradigms which are familiar to the students in order to maximize its usability. The application will be developed in HTML5 in order to make them highly portable to any mobile device as well as personal tablets and laptops.

The pedagogical methodology should support students learning the curriculum content at the same time as they learn how to use the technology. The teacher will ask students to perform certain learning activities individually or collaboratively, in or outside the classroom while monitoring in real time or asynchronously the students’ performance, in order to analyse them reflectively in the classroom.

Therefore, the applications developed should support teacher and student roles with different functionalities. For example, the teacher’s application should allow her to define and assign tasks students will receive in their devices, participate in them and provide timely feedback, revise the results of tests and assess students’ work.

The functionalities of the applications students will use should allow them perform tasks introducing the “21st Century ICT Skills” and curricular content simultaneously. A brief description of some tasks examples are described in Table 1.
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<td>Information</td>
<td>ICT skills in sourcing for information</td>
<td>(1) Define required information.</td>
<td>&quot;21st Century ICT Skills&quot;: (1), (3), (4) Educational Content (9): &quot;Reflection over artistic texts analyzing various human issues, experiences, concerns and interests&quot;. Students search for information inside and outside the classroom and in the internet. They record and organize the information in microblogging sessions with their mobile devices. They will evaluate the information and relate it, posing short questions to their classmates and to the teacher in microblogging sessions.</td>
<td>&quot;21st Century ICT Skills&quot;: (1), (3), (4) Educational Content (9): &quot;characterize geographically the urbanization process, the demographic transformations and the cultural diversity of the world today&quot;. Students geo-reference places as a result of their searching, selection and observation of social realities process; they produce opinions and characterizations of the diversity through microblogging sessions, organize and evaluate the information they found, they pose questions and give answers; the teacher will interact with the students.</td>
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<td>ICT skills in processing information</td>
<td>(2) Search for and select information in digital sources.</td>
<td>&quot;21st Century ICT Skills&quot;: (7), (9), (10) Educational Content (9 &amp; 10): &quot;Write individually or collaboratively texts which express, narrate, describe facts, subjects, judgments or personal visions of the world&quot;. The ideas and opinions proposed by the students regarding the text are described, analyzed, refined and represented in a short way through microblogging sessions. Images and/or videos produced outside the classroom may complement the contributions.</td>
<td>&quot;21st Century ICT Skills&quot;: (7), (9), (13) Educational Content (10): &quot;Understand that the Chilean nation/state and the dynamics of its geographical territory were developed historically&quot;. Students analyze, characterize and represent individually or collaboratively geographical sectors in the region via geo-referentiation; they associate information taken from the internet while located in real places outside the classrooms; they generate their own ideas; decide which are the most representative sectors.</td>
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<td>ICT skills in effective communication</td>
<td>(3) Evaluate digital information.</td>
<td>&quot;21st Century ICT Skills&quot;: (14), (15), (17) Educational Content (9 &amp; 10): &quot;Participate in communicative situations, deepening ideas, planning actions and making decisions&quot;. Students interact in microblogging session and outside the classroom, communicating their opinions, ensuring the contents are transmitted effectively. At the same time the teacher models these interactions face-to-face or virtually.</td>
<td>&quot;21st Century ICT Skills&quot;: (14), (15), (17) Educational Content (9): &quot;Interpret and issue information from various sources for the analysis of the geographic, demographic social and economic processes&quot;. Students translate and perform georeferentiations on maps of the various geographic, demographic social and economic processes. They are transmitted in a clear and simple way to their classmates and to the teacher, ensuring the meanings are understood.</td>
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<td>ICT skills in collaboration and virtual interaction</td>
<td>(4) Organize and manage digital information.</td>
<td>&quot;21st Century ICT Skills&quot;: (18), (19), (20) Educational Content (9 &amp; 10): &quot;Collaboratively produce reports about readings, commercial and propagandistic announcements, participation in forums in the internet, personal blogs&quot;. Students collaboratively interact through short messages in various microblogging sessions expressing their opinions through comments, posing questions, giving answers, negotiating agreements and making decisions.</td>
<td>&quot;21st Century ICT Skills&quot;: (1), (3), (4) Educational Content (9): &quot;Collaboratively issuing of web-based opinions about problems of the contemporary society considering its complexity&quot;. Students collaboratively elaborate reports on geo-referenced data on maps about contemporary social problems in Chile. They interact through microblogging sessions associated to georeferentiations over maps, they will pose questions and issue answers, negotiating agreements and making decisions.</td>
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<td>Ability to evaluate ICT Social impact</td>
<td>(5) Knowledge of information media and sources.</td>
<td>&quot;21st Century ICT Skills&quot;: (22), (23), (24) Educational Content (9 &amp; 10): &quot;Evaluate what they read about a subject contrasting it with their own or others position&quot;. Students interact through microblogging sessions in order to communicate their opinions and critics of content in the internet, taking care to be balanced in their interventions; they consider ethical and cultural aspects and risks associated to the use of internet.</td>
<td>&quot;21st Century ICT Skills&quot;: (22), (23), (24) Educational Content (10): &quot;Apply continuity and changes criteria in order to analyze political, economic, social and cultural changes which happened at the origins of republican Chile&quot;. Regarding diverse cultural and social aspects of Internet, students geo-reference places (with images and text) and express their opinions and critics about ethical aspects, pose questions, issue answers through microblogging sessions.</td>
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<td>Ability to evaluate Responsible use</td>
<td>(6) Investigation and research.</td>
<td>&quot;21st Century ICT Skills&quot;: (26) Educational Content (9 &amp; 10): &quot;Reflecting and commenting about the effectiveness of the communication media and their role in the transmission and broadcasting of information and ideas/opinions&quot;. Students will simulate the transmission and broadcasting of ideas/opinions of social issues identified outside the classroom in order to understand the impact of the ICT in their own social and cultural contexts.</td>
<td>&quot;21st Century ICT Skills&quot;: (26) Educational Content (10): &quot;Appraise the contribution of diversity of traditions, peoples and cultures in the historic development of the national community&quot;. Students’ geo-reference places and comment via microblogging the characterizations, behavioral patterns and reasoning principles of the various social classes in Chile and the social interaction among them.</td>
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<td></td>
<td>Ethics &amp; Social impact</td>
<td>(7) Investigation and research.</td>
<td>&quot;21st Century ICT Skills&quot;: (26) Educational Content (9 &amp; 10): &quot;Reflecting and commenting about the effectiveness of the communication media and their role in the transmission and broadcasting of information and ideas/opinions&quot;. Students will simulate the transmission and broadcasting of ideas/opinions of social issues identified outside the classroom in order to understand the impact of the ICT in their own social and cultural contexts.</td>
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Mediation mechanism | Microblogging | Microblogging and Geocollaboration |
HYPOTHESES:

- **H1.** Pedagogical practices supported by mobile applications using microblogging and geocollaboration promote the acquisition of “21st Century ICT Skills” while learning 9th and 10th grade curriculum content. Testing this hypothesis is related to the Specific Goal 5 described below.

- **H2.** The learning outcomes of curriculum content supported by these pedagogical practices are significantly higher when the applications’ design includes skills of the three dimensions: **information** (as source and as product), **communication** (effective communication, and collaboration and virtual interaction) and **ethics and social impact** (to evaluate ICT responsible use, and social impact), of the “21st Century ICT Skills”. Testing this hypothesis is related to the Specific Goal 5.

- **H3.** The development of the mobile applications implementing the pedagogical practices allows us to characterize and conceptualize a taxonomy and define a methodology, which allow the description of other similar mobile applications supporting learning in other fields as well as for other learning stages. Testing this hypothesis is related to the Specific Goal 6.

GOALS: Specify your general and specific goals.

**General Goals.**

Developing collaborative pedagogical practices to acquire “21st Century ICT Skills”, while learning 9th and 10th grade curriculum content using microblogging and geocollaboration in mobile learning scenarios.

The “21st Century ICT Skills” chosen dimensions are: 1) **information**, 2) **communication**, and 3) **ethics and social impact**; and the learning areas chosen from the Chilean Ministry of Education’s curricula are: a) “Language and Communication”, and b) “History, Geography and Social Sciences”.

To do this, we will develop two collaborative applications using mobile devices, one for each learning content area, that support these pedagogical practices in public Chilean classrooms of up to 40 students with 6-8 week pilot tests.

The technological mediation mechanisms implemented for each learning area are as follows: a) “Language and Communication”, mediated by microblogging services, to provide educational activities involving information exchange and communication, and promote social interaction between students and teachers. b) “History, Geography and Social Sciences”, mediated by microblogging services and geocollaboration functionalities, to provide activities involving information exchange and communication, and collaborative georeferencing on virtual maps when students are located in physical contexts.

Developing a taxonomy and a methodology based on the knowledge gained during the project will allow for the development of the “21st Century ICT Skills” to be applied as a basis to other curriculum content for different learning areas and grade levels.

**Specific Goals.** The specific goals are:

1. Identify, analyze and characterize the results of existing studies similar to the present proposal regarding methods for supporting educational activities in and outside of the classroom using mobile devices. Some of the aspects to be covered are: use of mediation mechanisms based on microblogging and geocollaboration, application of learning theories, advantages and disadvantages of various mediation mechanisms, possible guidelines or taxonomies, etc.

2. Specify and design two collaborative applications for mobile devices that support pedagogical activities and practices which will develop the “21st Century ICT Skills” as well as achieving the fundamental concrete objectives specified for 9th and 10th grade curriculum content to be deployed in the classroom. This will be done by an iterative approach of rapid development of early prototypes. One application uses microblogging services and is aimed at the LC learning area while the other employs microblogging and geocollaboration services and is intended for the HGSS learning area.

3. Development of a software toolkit in HTML5 for implementing the two collaborative applications proposed, and an iterative approach, which will systematize the mediation mechanisms and specified functionalities, to provide the necessary technological support for developing simultaneously the “21st Century ICT Skills” and the fundamental curriculum content objectives specified for the 9th and 10th grades.

4. Evaluate the usability and utility of the two collaborative applications with experts, students and teachers in real and simplified scenarios, and improve the applications based on the results of the evaluations.

5. Validate the implemented applications using collaborative application evaluation methods and experimental evaluations with 9th and 10th grade students and teachers. This is to be done for each course, and learning area in two public different schools (belonging to the poorest quintile of the school system), in and out of the classroom (in real, concrete scenarios spatially located in environments similar to those encountered by the students in daily life and at their school in Santiago, Chile), over periods of 3 to 4 weeks in each case, around 24 to 32 weeks in total. The evaluations will be designed to demonstrate whether it is possible to simultaneously develop the “21st Century ICT Skills” and curriculum content using collaborative applications running on mobile devices with microblogging services and geocollaboration functionalities that can be used in and out of the classroom. The results obtained are then analyzed.

6. Develop a taxonomy and a methodology based on the knowledge generated during the execution of this project and the validations carried out so that development of the “21st Century ICT Skills” can be generalized to other curriculum content at various grade levels and in different learning areas.
METHODOLOGY:

To fulfill the goals defined for the project, the proposed methodology is built around the execution of 6 steps for designing, implementing, evaluating and validating two collaborative applications that support educational activities. One of the applications uses technological mediation mechanisms based on microblogging while the other employs technological mediation mechanisms based on geocollaboration in addition to geocollaboration functionalities. In both cases, for working with 9th and 10th grade educational content and oriented at new ways of introducing educative contents and the development of "21st Century ICT Skills" simultaneously. Initially, the application utilizing microblogging will be developed to support pedagogical practices in the LC; and the experience and knowledge so generated will then be reused to apply the microblogging services and geocollaboration functionalities to the HGSS (see Gantt chart).

The computer mediation services provided by microblogging and geocollaboration are widely available technologies on mobile devices and are increasingly used in a variety of contexts as were summarized in sections 2.2.1 and 2.2.2 of the present proposal. According to the literature survey conducted for this project, these services have been intensely applied in recent years to implement a range of pedagogical practices supporting learning in and out of the classroom, although without the simultaneous consideration of the "21st Century ICT Skills" and without formal curricula educational contents in their designs as is intended in this proposal. In section 4, a detailed overview of the two collaborative applications to be developed are described.

Step 1. To identify, analyze and characterize the results of existing studies similar to the present project that use wirelessly interconnected mobile devices to support collaborative educational activities in and out of the classroom (Specific Goal 1), the following activities considered as the most important, will be carried out:

a. Identification of existing works similar to the present proposal that use mediation mechanisms such as microblogging, geocollaboration and others, on mobile devices as support for various teaching-learning activities in and out of the classroom. Characterization of their experiences, knowledge gathered and conclusions drawn from different mobile device-supported learning situations, emphasizing in particular those using collaboration/constructivism and support activities.

b. Analysis and characterization of the contribution of microblogging to pedagogical practices. Analysis of the various communication mechanisms for supporting both social interaction among users and functional interaction among mobile devices for the creation of collaborative work environments, which facilitate positive interdependence, coordination, negotiation, rule compliance, support for roles, etc.

c. Analysis and characterization of diverse developments and research in geographic information collaborative systems, and their contribution to support learning processes. Analysis of different uses in other scenarios: crisis management, decision-making to find ways of transferring these benefits to situated learning scenarios. Advantages and disadvantages of the different collaboration modes offered will also be identified.

d. Analysis of similar research works which have considered the three dimensions: information (as source and as product), communication (effective communication, collaboration and virtual interaction), and ethics and social impact, of the "21st Century ICT Skills" in the design of mobile learning applications.

e. Analysis and characterization of various applications related with the present proposal in the area of learning supported by microblogging, and/or geocollaboration. Identification of developments related to diverse methodologies of design, implementation and evaluation of mobile learning applications.

Step 2. To specify and design the two collaborative applications (Specific Goal 2), detailed software designs for mobile devices will be built that facilitate development of the "21st Century ICT Skills" among 9th and 10th grade students using:

a) microblogging services, for achieving the fundamental objectives of the LC area; and b) microblogging services and geocollaboration functionalities, for achieving the fundamental objectives of the HGSS area. We will incorporate the principles for mobile application design described in section 2.3. The most relevant activities to be performed are:

a. Detailed specification of the fundamental objectives and learning content of: the LC learning area, which can be supported via mobile device mediation technologies and microblogging services; and the HGSS area, which can be supported via mobile device mediation technologies, microblogging services and geocollaboration functionalities.

b. Detailed specification of the "21st Century ICT Skills" to be used as examples for the information, communication and professional ethic dimensions, and also of ways in which they can be integrated into the fundamental objectives of both the LC and HGSS areas. Some examples of the educational activities and learning outcomes (referring to item a. of this step), and their relationship with the "21st Century ICT Skills" were explained in the Novel Aspect 1 of section 3. This and the previous item will be implemented with the help of educational experts of middle schools working at the Ministry of Education and university researchers. Detailed design of software components architectures, data structure, modularization, simple software interfaces will be done; ensuring compatibility between the different mobile device platforms and especially maintaining extensibility, modularity, reusability and robustness. The designed applications will include multimedia data management (video, images, photos, files, etc.) that extend and enrich the information shared among the students when they use the microblogging services and the GPS on the mobile devices to geolocate data while they are in physical locations associated with real and specific contexts. Some features of the mobile learning applications to be designed were described at the end of Novel Aspect 1 of section 3.

c. Design of the wireless interconnection architecture to be used in the classroom through the Wi-Fi access point, and outside the classroom using 3G; and the necessary mechanism to share and synchronize data.
d. Detailed design of the two applications, the first one using microblogging services for LC area content; and the second using microblogging services and geocollaboration functionalities HGSS area content. The design of both will initially be developed using fast methods such as “prototype design,” which is useful for building software interfaces in collaboration with the final users. More traditional methods such as “agile” and “spiral” development will then be employed to specify the detailed design of the software interfaces and the applications’ respective functionalities. Extended versions of each application for use by the teacher will also be built, with additional functionalities for managing, supervising and following up on technologically mediated educational activities performed by the students both in and out of the classroom.

Upon completion of this step, an article will be written containing the theoretical aspects identified and the proposal of the collaborative application for LC area to be submitted to an academic conference.

**Step 3.** To develop a software toolkit for implementing the two collaborative applications (Specific Goal 3). The development of the toolkit will include a set of libraries (some already constructed and others to be implemented). The environment of HTML5 with JavaScript will be used as it can be run on most popular Web browsers of any mobile devices, and is therefore independent of the operating system. The applications will thus be executable on a variety of mobile devices operating systems including iOS, Android, Windows Mobile and BlackBerry OS. Applications will make use of human-computer interaction mechanisms available on mobile devices (Smartphones) with high-resolution touch screen and high processing capacity of data given the high requirements of the functionalities that will be implemented. Some of these functionalities will be: a) displaying information (maps, pictures, texts, etc.) using various views and modalities; b) capturing high-resolution photographs and associate them with maps and text; c) registering physical positions over maps via GPS, and associate it with diverse data types; d) managing various views associated with microblogs; e) establishing wireless communications anytime and anywhere using 3G, and/or Wi-Fi networking capabilities; f) synchronizing data on a central server; g) utilizing different mechanisms to facilitate the information exchange among users; h) utilizing various data managing structures, such as lists, conceptual maps, relations, etc. The following activities will be carried out:

a. Implementation of the software components and libraries of the toolkit, and the data structure, modules, etc.; using HTML5 and JavaScript. Testing the compatibility of the functionalities with distinct mobile devices and on diverse Web browsers.

b. Implementation of the wireless interconnection architecture. In classrooms and other locations on school premises where the applications will be used, interconnections will be handled by Wi-Fi (which will be employed in particular for the usability and utility evaluations). Outside of the school, Smartphones using 3G will maintain wireless connectivity.

c. Implementation of the previously designed applications.

d. Testing of application functionalities (microblogging, geocollaboration, data flow, data storage, software interfaces, etc.) and performance regarding both the establishment of wireless interconnections and the correct functioning of software interfaces.

**Step 4.** To evaluate the usability and utility of the two implemented collaborative applications with experts, students and teachers in real and simplified scenarios (Specific Goal 4), the following activities will be conducted:

a. Application of investigative and heuristic evaluation methods by experts in the areas of teaching-learning, computers and collaborative application development. The tests will be carried out mainly through interviews, surveys, focus groups, etc. with experts. The results obtained will be used to identify areas in the applications for improvement or modification before testing with actual users is undertaken.

b. Usability evaluation, complemented by the design of measurement and data gathering instruments to be applied in “usability studies” of the applications with actual users (9th and 10th grade students and teachers) in and out of the classroom. The quantity of users involved will be the maximum number that can be covered with the 40 mobile devices requested for this project. The tests will be conducted using methods and techniques of observation (backed by video recordings), follow-up, surveys and interviews with students and teachers, etc.

c. Testing the utility of the applications in simplified environments and over reduced time periods (from 1 to 2 weeks) with actual student and teacher users: proof of concept. The number of student participants will be 12 to 15, which is the minimum required to perform a collaborative learning activity. To measure application utility, the technology acceptance model (TAM) [15] or other similar, will be used in order to determine the factors influencing the decision of users about how and when they will use the applications.

d. Analysis of the evaluation results. Feedback from the evaluations will be translated where necessary into improvements to the system through reengineering of the applications and fine-tuning of the designed mediation mechanisms.

Upon completion of this step, two articles will be written containing the usability results of the collaborative application for LC area to be submitted to an ISI journal and an academic conference.

**Step 5.** Validation of the implemented applications using collaborative application evaluation methods and experimental evaluations (Specific Goal 5) to determine whether the "21st Century ICT Skills" and curriculum content can be simultaneously developed using collaborative applications running on mobile devices with microblogging services and...
geocollaboration functionalities in and out of the classroom. The school will be chosen of the poorest quintile of the School system. We suppose that most of the students will not have an own smartphone and therefore we will conduct tests about their skills using technology before and after they have learned using the methodology and tools developed in this project. The evaluations will be conducted separately for each grade (9th and 10th), learning area (LC and HGSS) in and out of the classroom in real, specific scenarios spatially located in environments similar to those encountered by the students in daily life, for periods of 3 to 4 weeks in each case. The number of student to be considered in each classroom will be up to 40. The distribution of the evaluations is summarized in Table 2.

The activities to be carried out are the following:

a. Evaluation of the collaborative applications using rule-based performance methods, (emphasizing the importance of individual performance) and knowledge-based performance methods, [88] (emphasizing group variables). These methods, explained at the end of section 2.3, analyze the information flow within a group and cognitive-level experiences of the individual; which will be fully designed once the application has been developed and the characteristics of their application to real contexts identified. Exact determination of the universe (private and partially subsidized schools that have already been evaluated for “21st Century ICT Skills”), the samples (two 9th grade classes at two schools that will use both applications, i.e., four classes; and two 10th grade classes at two schools that will also use both applications, i.e., four more classes), the procedures (determined by characteristics of the experiment and the independent variable to be measured), the time periods (3 to 4 weeks for each application, scheduled sequentially due to the number of available mobile devices), and the specific learning content of the control groups (using similar microblogging and geocollaboration mobile devices applications without any component that include dimensions of the “21st Century ICT Skills”) and the experimental groups (using mobile devices with microblogging and geocollaboration services and dimensions of the “21st Century ICT Skills” simultaneously. Therefore, the principal independent variable of the experiments is the dimensions of the “21st Century ICT Skills”. The total expected time for the experiments is around 24 to 32 weeks.

b. Design of measuring instruments: pre-test and post-test (to measure the degree of learning achieved in the control and experimental groups, and the degree of the three dimensions of the “21st Century ICT Skills”: information, communication, and ethics and social impact), and observations used as primary data gathering and measuring instruments (e.g., backed by video recordings of the activities performed in the classroom, and interviews and questionnaires for the activities performed out of the classroom; both for later analysis, evaluation and interpretation of data, according to rule-based and knowledge-based methods explained in section 2.3). The instrument used by the Ministry of Education in 2009 will be employed with the 10th grade students as a base for measuring the “21st Century ICT Skills”, and can be extended and/or modified for purposes of the project. Also, student and teacher interviews, surveys, student and teachers focus groups, etc. will be designed and applied as sources for validating the observations.

c. Training of students and teacher in the use of the collaborative applications. Test run with control and experimental groups in the classroom to check for necessary adjustments in procedures, time periods, etc., followed by definitive application to the groups and data collection. Students will be trained in order to have them all acquired a similar base skill.

d. Statistical analyses of results of experimental evaluations. Determination of significant differences in defined goal outcomes (development of skills in using ICTs to solve various problems, quality of social interaction, participation, follow-up, student participation, motivation, etc.) between the control group and the experimental group. Pre- and post-intervention Student’s t testing, analysis of covariance to check for significant differences between the control and experimental groups in post-treatment measurements discounting any observed differences in pre-treatment measurements.

Upon completion of this step, an article will be written containing the evaluation results of the collaborative application for LC area to be submitted to an ISI journal. We envision that this will be the step which will take the longest time to develop, as shown in the Gantt chart.

**Step 6.** To develop a taxonomy and the methodology proposed in Specific Goal 6, the following activities will be carried out:

a. Identification of 1) characteristics, key components, their interrelationships and how they relate to the activities and pedagogical practices supported by the mobile devices through microblogging and geocollaboration services used in achieving the fundamental objectives; 2) types, principles of classification, and key components of the “21st Century ICT Skills” that can be supported by the developed applications, and their relationships with the components identified in 1) above.

b. Identification of the relevant learning theory for collaborative applications using microblogging and geocollaboration in and outside of the classroom.

c. Building of a taxonomy that explains the collaborative applications developed for the project and their use in simultaneously developing the “21st Century ICT Skills” and curriculum content with microblogging services and geocollaboration functionalities used in and out of the classroom. This taxonomy also can be used for other similar collaborative applications in different grades, contents, and ICT Skills.

d. Validation of the proposed taxonomy with expert panels.

e. Definition of a proposed methodology based on the development of the project, the various aspects that will be conceptualized and implemented, the results of the experimental validations and the general taxonomy. The methodology will explain, develop and be usable to build similar collaborative applications with other fundamental educational objectives for different learning areas and grades.

Upon completion of this step, two articles will be written describing the final results of the project research to be submitted to an ISI journal and an academic conference.
**WORK PLAN:** Gantt Chart. Stages and activities to be carried out each year.

LC = "Language and Communication", HGSS = "History, Geography and Social Sciences". According to the methodology, the steps 2, 3, 4 and 5 will be applied twice in different years, one for each collaborative learning application.

**Steps of the Methodology**

- **Step 1.** To identify, analyze and characterize similar existing works
  - Identification of works about microblogging and geocollaboration on mobile devices
  - Analysis of microblogging and geocollaboration learning applications
  - Characterization of microblogging and geocollaboration learning applications

**APPLICATION FOR LC USING MICROBLOGGING**

- **Step 2.** To specify and design the collaborative application for LC
  - Specification of the fundamental objectives and learning content of LC
  - Specification of the "21st Century ICT Skills" to be applied in LC
  - Design software components, data structure, wireless infrastructure, etc
  - Design of the collaborative application for LC using microblogging
  - Writing a Conf. Paper: theoretical aspects identified LC application

- **Step 3.** To implement the collaborative application for LC
  - Implementation of the software toolkit, data structure, module, etc
  - Implementation of the wireless interconnection architecture
  - Implementation of the collaborative application for LC using microblogging
  - Carry out testing of application functionalities and performance

- **Step 4.** To evaluate the usability and utility of the application for LC
  - Application by experts of investigative and heuristic evaluation methods
  - Design of measurement and data gathering instruments to "usability studies" with users
  - Testing the concept in simplified environments of the application for LC
  - Analysis of the results obtained on the evaluation of the application for LC
  - Improvements and reengineering of the application for LC using microblogging
  - Writing a ISI Paper: usability of the application tested

**APPLICATION FOR HGSS USING MICROBLOGGING & GEOCOLLAB**

- **Step 2.** To specify and design the collaborative application for HG&Ss
  - Specification of the fundamental objectives and learning content of HGSS
  - Specification of the "21st Century ICT Skills" applied to HGSS
  - Design of the collaborative application for HGSS

- **Step 3.** To implement the collaborative application for HGSS
  - Implementation of the application for HGSS, using microblogging & geocollaboration
  - Carry out testing of collaborative application functionalities and performance

- **Step 4.** To evaluate the usability and utility of the application HGSS
  - Application by experts of investigative and heuristic evaluation methods
  - Design of data gathering instruments to be applied in usability studies with users
  - Testing the concept in simplified environments of the application for HGSS
  - Analysis of the results obtained on the evaluation
  - To identify possible improvements to the collaborative application for HGSS
  - Reengineering of collaborative application and fine-tuning of the mediation mechanisms

- **Step 6.** Evaluation of "21st Century ICT Skills" and HGSS learning area
  - Application evaluation using rule-based and knowledge-based performance methods
  - Determination of universe, samples, procedures, learning contents, experimental groups
  - Design of measuring instruments for experimental evaluation
  - Training and experimental test of the collaborative application for HGSS
  - Experimental evaluations of the application for HGSS learning area
  - Statistical analyses of results on experimental evaluation
  - Writing a ISI Paper: evaluation results of the application for HGSS

**Steps in the development of the collaborative application for LC using microblogging services**

**Steps in the development of the collaborative application for HGSS using microblogging and geocollaboration services**

**Writing paper**

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2016 FONDECYT Regular Competition
PRIOR WORK ON THE PROPOSAL TOPIC BY THE AUTHOR(S):

As results from previous research, we can identify the results of following works already developed in previous projects as substantial inputs for the achievement of the proposed objectives for the present one:

• A platform with components allowing the implementation of diverse functionalities to synchronize, take notes through sketches on Tablet-PCs and PDAs, [89].

• A prototype of a mobile collaborative application supporting georeferenced knowledge creation and management using Tablet-PCs and GPS, [90]. Use of geocollaboration system to support knowledge creation for urban planning, [91]. Supporting knowledge management in collaborative learning environments using PDAs, [92].

• A basic system implementing geocollaboration using maps from Google, which allows collaborative work in the four (synchronous, asynchronous, same and different place) collaboration groupware modes, [93]. A model for integrating spatial data (georeferenced) and decision support with a geocollaborative tool, [94]. A geocollaborative system supporting in-situ group therapy, [95]. The identification of the key indicators for assessing the design of geocollaborative applications, [96].

• A framework for developing collaborative activities to boost social interaction between students and the teacher and students among themselves, easing coordination and students’ negotiation; and their methodology of instantiation with concrete educational contents at basic level, [28, 93, 97-99].

• Collaborative instances and a conceptual framework supporting learning activities based on contextual information, [97, 100]. A learning system based on mobile devices and a methodology based on the use of patterns. Students learn about design and architectural patterns by finding instances of them outside the classroom, [101]. Development of mobile collaborative applications with primary, secondary and undergraduate educational learning contents, [34, 92, 97, 100]. A conceptual model to facilitate the design of partially virtual communities applied to support the learning process [91].

• The use of services offered by Google Maps to implement educational computer applications in undergraduate university level courses, for implementing learning activities based on situated learning [80, 81]. These applications are oriented to provide pertinent geographical information and discussion boards for the support of decision making processes [80], and for identifying problems and Opportunities for Technological business, [79].

Moreover, there is a software platform already developed with HTML5, JavaScripts and other libraries and software component, which will be used as basis for the implementation of the proposed applications

AVAILABLE RESOURCES:

In order to implement collaborative applications (see both steps 3 on the Gantt chart, one for year 1, and another for year 2), there is one computer with the proper processing capacity needed to development of these applications.

Other available equipment that will allow usability and utility testing (see both steps 4 on the Gantt chart, one for year 2 and another for year 3), and the corresponding validations (see step 5 in methodology) are Camcorder, Data show and a Notebook.