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The 4SPPIces factors in a collaborative learning script blending spaces: a case study

Abstract

Computer Supported Collaborative Blended Learning (CSCBL) scripts are complex learning situations in which formal and informal activities happening in different spatial locations are coordinated and integrated into one unique learning setting through the use of technology. 4SPPIces is a conceptual model that defines 4 factors to be considered when addressing the design of these CSCBL scripts and of the technological system for supporting their enactment: the Space, the Pedagogical Method, the Participants and the History. This paper presents and evaluates a CSCBL script designed according to the 4SPPIces factors. The script is proposed for extending an actual learning geography fieldwork of a Geography course at a high school in which students reflect about the urbanism and the socio-geographical characteristics of Barcelona city. The resulting script blends individual with collaborative activities supported by mobile and computer-based technologies conducted at the classroom, home and the city. The script is evaluated in a case study with 34 students and two teachers. The case study reports: (1) the CSCBL script designed with the teachers considering the 4SPPIces factors and its associated technological environment and (2) the results of enacting the script in the actual learning context to analyse whether it fulfils the targeted learning objectives. The results from this case study show the impact and the effects of considering the 4SPPIces factors to enhance a real practice providing new learning and motivational benefits. Moreover, the CSCBL script presented is an example that can encourage other practitioners and researchers to adopt the 4SPPices factors in similar educational situations.

Keywords *Computer Supported Collaborative Learning Script, Blended Learning, Educational spaces, Mobile learning, Case Study.*

Introduction

In recent years, devices such as mobile phones or PDAs combined with wireless connectivity are changing the nature of educational practices. Now learners are not at a fixed predetermined location and can move across different spaces. Collaborative learning can occur both in and beyond the classroom. Furthermore, formal activities with other actions that have been traditionally informal can be monitored and orchestrated across spatial locations leading to a new type of collaborative blended learning (CBL) practices (Roschelle, 2003; Kukulska-Hulme et al, 2005; Kurti et al., 2008; Spikol and Milrad, 2008; Roschelle et al., 2010).

The study by Facer et al. (2004) is an example of these CBL practices. This study proposes using mobile phones for supporting a collaborative experience in which children are invited to understand the animal behavior in a savannah in direct physical interaction with space. The results show that, despite of its complexity, the experience fostered students' motivation and helped the acquisition of concepts. In another study by Ruchter, et al. (2009) mobile devices are used by a group of users as a guide for supporting environmental learning. The conclusions of this study show that using mobiles leads to an increase in students' environmental knowledge and in their motivation in environmental education activities. Also, a work by Lim (2006) suggests that using mobile phones as a tool for collaborative learning around two geographical tasks augment spatial intelligence and mapping skills.

The main interest of these CBL practices falls on their blended nature and their innovation in terms of technology usage and learning benefits. But, what makes these practices especially interesting for learning is that the use of technology is always driven by educational considerations. That is to say, the technologies employed are selected not only for the functionalities that they offer but also for the way in which their functionalities effectively support and enhance the learning purposes.

One of the major difficulties of CBL practices when enacted in actual educational context relies on coordinating and monitoring the different activities so as to produce effective collaboration. CSCL scripts (Stahl, 2005; Dillenbourg & Fischer, 2007) are a well-know solution for technologically coordinating (or

orchestrating) collaborative learning so as to lead to situations of effective learning. In the context of this paper and by analogy with CSCL scripts, we refer to CSCBL scripts as the means for coordinating a CBL practice. CSCBL scripts can be therefore defined as a type of CSCL scripts for supporting the coordination of collaborative practices that combine formal and informal activities occurring across different spatial locations.

Because of their multidisciplinary nature, the design of CSCL scripts and of the applications for their support implies a balance between technology and education (Larusson & Alterman, 2009). But to keep this balance is even more complex when facing the design of CSCBL scripts (Park et al., 2010). New factors such as the spatial locations and the interplay between formal and informal activities have direct implications on the way collaboration is organized that have to be understood from both educational and technological perspectives.

Designing potentially effective CSCBL scripts requires the intervention and the mutual understanding of mainly two different actors: practitioners (experts in educational issues) and technicians or technologists (aware of the technologies available and their potential) (Dimitriadis et al., 2003). Both practitioners and technicians have to work hand in hand to end up with meaningful CSCBL scripts and educationally driven technological environments for effectively supporting their enactment.

4SPPIces is a conceptual model for supporting communication between practitioners and technicians when facing the design of CSCBL scripts and of the technological environment supporting their enactment. 4SPPIces considers 4 factors: the Space, the Pedagogical Method, the Participants and the History. These 4SPPIces factors constitute a framework that yields insights in the complexity of CSCBL scripts for facilitating a conceptualization of the elements that describe them and which have to be considered in their design.

This paper presents the results of an illustrative case study in which a CSCBL script designed considering the 4SPPIces factors is enacted in a real situation with 2 teachers and 34 students. Specifically, the CSCBL script is proposed to solve the limitations of a fieldwork activity framed in a Geography course that takes place every year at the high school Duc de Montblanc of Rubí (a town close to Barcelona). The activity consists in a visit to Barcelona to foster students' familiarization with the urbanism and the socio-geographical characteristics of the

different districts of the city. The two teachers involved in the Geography course set off the limitations about the past editions of the activity: (1) The activity is programmed to spend one morning in the city, which constraints the visit to only one area in Barcelona and hinders comparing different districts of the city; (2) The visit is prepared as an individual activity but teachers are interested in introducing a collaborative component to promote student's competences of working in groups and critical thinking; and (3) Teachers are interested in using Information and Communication Technologies (ICT) to adapt to the new curriculum (see Catalan High School Curriculum).

The main research question addressed in this case study is: *Does considering the 4SPPIces factors help practitioners and technicians in the design of a meaningful CSCBL script for extending an actual geography fieldwork to overcome the limitations detected its previous editions?* Specifically, two research questions derived from the main question are analyzed: (1) Does the CSCBL script designed considering the 4SPPIces factors cover the demands of the teacher for the specific geography context? and (2) Does the technological environment associated to the CSCBL script supports students' and teachers' tasks? The results of this case study show the effects of considering the 4SPPIces factors for improving a real educational situation.

After presenting the 4SPPIces model in the next section, the following section presents the context of the case study and the main research objectives to be addressed. Next section describes the methods and analytical strategies used for evaluating the CSCBL script. First, we report the CSCBL script designed with the practitioners. Second, we describe the results of running the CSCBL script. The final section discusses how the results of the case study provide answers to the research questions and draws conclusions concerning the benefits of considering the 4SPPIces factors to design suitable and meaningful CSCBL scripts.

4SPPIces: a model for designing CSCBL scripts

4SPPIces is a conceptual model that provides practitioners and technicians with a common language to design CSCBL scripts and the technological setting for supporting their enactment. 4SPPIces combines 4 factors conditioning the design of CSCBL scripts: the *S*pace, the *P*edagogical method, the *P*articipants and the H*i*story. These factors have been studied separately in the literature, with special

emphasis on the pedagogical method and the participants. The novelty of 4SPPIces falls on: (1) combining these factors in one unique representation, (2) explicitly defining the space as a relevant factor to be considered during the design and (3) highlighting the role of the history to explicitly model the relations between the other factors that affect the script enactment. Research on theoretical models sheds light over how to consider all the aspects in a holistic and integrated manner in regard to the design of CSCBL scripts. Next subsections revise these theoretical models and present the definition of the 4SPPIces factors and their facets.

Approaches towards the design of complex collaborative activities

First, we adopt the ideas behind the constraint-based flexibility framework by Dillenbourg and Tchounikine (2007) and the SPAIRD (Tchounikine, 2008) and SWISH (Dillenbourg & Jermann, 2007). These approaches underline the importance of designing flexible systems in order to be able to support the unexpected events typical in the enactment of CSCL scripts. In all these models, flexibility is defined in terms of intrinsic and extrinsic constraints. The intrinsic constraints arise from the principles on which the script has been based and must be respected in order to achieve a fruitful collaboration. The extrinsic constraints arise from those elements induced by the technology of contextual factors (limitations in the number of students, evaluation elements, etc). The proposed dissociation of constraints marks the boundaries of flexibility for both teacher and students, and provides the basis for a computational platform of interaction. This platform should be sufficiently flexible to maintain interaction patterns in the light of extrinsic constraints, without violating the intrinsic constraints in each of the phases of the script development process (edition, instantiation and enactment).

Second, we incorporate the space factor inspired by models of mobile learning such as the one by Sharples et al. (2010) and Spikol et al. (2008). These models hint at how to consider the space where the activity occurs as a conditioning factor in the design of CSCBL scripts and its relation with activities and technologies. In this paper, we consider that mobile learning activities, when structured and focused in collaboration, are a particular type of CSCBL scripts. Then, these models of mobile learning remark the importance of the space in relation with the other factors.

And third, the interrelation between the different factors is inspired by the 4C/ID four-component instructional model to design programs supporting complex skills acquisition by van Merriënboer et al. (2002). This model is an example of how different components of a different nature can be interrelated and integrated to facilitate the achievement of sets of learning goals. The idea behind the 4C/ID model is that environments for supporting complex learning have to coordinate and integrate activities to facilitate the attainment of sets of learning goals. CSCBL scripts are also complex learning situations that demand the integration of activities occurring at different spatial locations and supported with a variety of technologies. Thus, CSCBL scripts require the interrelation of different components according to a set of learning objectives. The 4C/ID model sets the basis of how the different identified factors can be related.

All these models incorporate some of the factors characterizing collaborative blended learning activities, such as the importance of the locations where learning activities occur or the flexibility that orchestration systems in blended learning settings demands. However, none of these models combine all these factors into a one unique representation stressing their relation with the activity learning flow or the characteristics of the participants involved in the activity. 4SPPIces disentangles all the factors involved in CSCBL scripts and integrate them making explicit how they are combined.

Factors and facets of 4SPPIces

Figure 1 shows a schema of the 4SPPIces factors, their facets and their inter-relations.

[FIGURE 1 goes here]

[**Figure 1** 4SPPIces model. Factors and facets to be considered in the design of CSCBL scripts and of the technological environment for supporting their enactment.]

First, the **Space factor (S)** defines the space where the learning activity occurs and its elements (Pérez-Sanagustín et al., 2010). Inspired in ideas coming from research works on learning spaces and ubiquitous computing, this factor represents the planned environment where the activity is going to take place, with the available technology. Researchers in these fields consider the physical space as a contextual factor that can enable or inhibit learning by shaping users'

interactions that can activate collaboration (Ciolfi, 2004; Gee, 2005; Oblinger, 2005; Oblinger 2006). The characteristics of the elements composing the space determine the interactions that can occur in that space. For example, whether the elements of the learning environment are portable or not, electronic or not, sharable or not, conditions the way students are distributed over the space and how they move or interact affecting the way in which the learning flow is defined (Pérez-Sanagustín et al., 2010). In this way, a learning space will be characterized by the *Arrangement* of the elements that compose it (location and organization of the elements composing the space), their *Mobility* (whether they are portable or not) and their *Affordance* (describes whether these elements are used individually, collectively or collaboratively). Notice also, that one activity of the learning flow may involve different spaces at the same time in case the students are distributed.

The second is the **Pedagogical Method factor (PM)**. The definition of this factor is prompted by the ideas that arise from the CSCL scripting field (Dillenbourg & Fischer, 2007; Dillenbourg & Hong, 2008; Weinberger et al., 2009). This factor adopts some of the concepts of the scripting practices and proposes: 1) to structure the activities, occurring in sequence or in parallel, in a *Learning flow*, 2) to differentiate the teachers' and learners' tasks through the *Activities*, 3) to define the *Group characteristics* for each activity and 4) to define the inputs and outputs that will be generated from one phase to another, which corresponds to the *Data flow*. The Data flow facet takes into consideration the ideas behind the concept of integrated scripts. These scripts contemplate a computational integration of the data used and produced across the different learning activities to define an integrated learning experience (Dillenbourg & Jerman, 2007). Therefore, the PM is any didactic description of a sequence of activities that define what learners and teachers should perform, the groups' characteristics for producing the interactions to reach the particular learning objectives and the data flow that assures the activities integration.

Third, the **Participants factor (P)** is dedicated to capture those aspects related with the students participating on the activity. 4 facets compose this factor. The first takes into account the *number of potential and actual number of participants*. This distinction is considered in order to design technological systems able to lead with the flexible requirements during the CSCBL script enactment related with the number of participants (Dillenbourg & Tchounikine, 2007). The second and

third facets are related. On the one hand, the students *Profile* facet takes into account those characteristics of the students that can affect the way in which the activity is structured. For example, we can have advanced and non-advanced students and assign one or another activity to each one. On the other hand, it is possible to group the different students according to the elements defined in their profile such as their language. This is modeled in the *Profile-dependent group formation* facet. Finally, the physical location of the students for each activity is also important. Now it is possible to conceive scenarios in which, for example, a group of students from Valencia attends to a class in Barcelona through an audiovisual conference system. Students can be *located* in one of the two spaces, Valencia or Barcelona, for the same activity. Since, in such as cases, the dynamic of the collaborative activity changes depending on the location of the students, the Participants factor includes the *Location* as one of its facets. Notice that, although the Space factor and the *Location* facet are related, they describe different aspects. While the Space describes all the spaces involved in the activities of the learning flow and their characteristics, the *Location* is related to the Participants and indicates where they are positioned within these spaces along the whole activity. Thus, although one activity may occur at different spaces at the same time, the position of the students in such activity will be determined by their location.

Finally, the fourth factor is the **H*i*story (I)**. The H*i*story describes what happened with respect to the facets of the previous three factors whose (unpredictable) variations affect the potentially fruitful activity enactment. This factor is inspired again in the research on CSCL scripts, especially in the above-mentioned studies about the flexibility needs during the scripts enactment. The literature distinguishes between three different phases when talking about scripting processes: the design phase (where the script is defined), the instantiation phase (when the script is related to the learning situation) and the enactment phase (when the instantiated design is delivered to the participants as an activity to perform) (Hernández-leo et al., 2006; Weinberger et al., 2009). Therefore, in order to design a technological support for the enactment of the CSCBL script, it is essential to consider those facets implied in all these phases. The nature of the H*i*story factor has to do more with those issues that, when the activity is enacted, need to be considered for assuring a coherent and integrated learning setting. For example, the role assigned to a student in the first activity can

affect the role that it is recommended (from the pedagogical method perspective) for this student to play in the second phase. With this aim, the H*i*story is characterized by three facets directly registering the flexibility requirements that have to do with the rest of the factors in the model: S events (those flexibility requirements regarding to the Space factor), PM events (those flexibility requirements regarding to the Pedagogical Method) and P events (those flexibility requirements regarding to the Participants factor). The idea behind this factor is to make the users of the model reflect about those relations among factors that can affect the enactment of the experience in order to build up systems and mechanism dealing with them.

4SPPIces in a real educational design: a case study

Case studies provide valuable information regarding the influence of technology in a particular context and have proved to be very useful on providing answers to 'How' questions (Rowley, 2002). As Zelkowitz & Wallance (1998) state, case studies enable monitoring an authentic situation by extracting information from the data collected about the different attributes characterizing its development. Thus, case studies help on evaluating how technology affect and transforms a context.

We propose an "instrumental" case study as the evaluation method that better fits our research scope. Instrumental case studies, beyond learning about the educational situation itself, are instruments for researchers to understand the implications of specific interventions in the context of the particular case and having general understanding about the research question (Stake, 1998). The intervention here has to do with the application of 4SPPIces into a real educational context for implementing a CSCBL script and its associated technological environment for supporting its enactment. 34 bachelor students of the second course and 2 teachers participated in the experiment.

This section presents the details of the case study to tackle the research questions. First, the CSCBL script designed and its associated technological environment implemented are described. Second, the methods and analytical strategies employed for addressing the CSCBL script evaluation are presented.

Design and implementation of the CSCBL script

The design of the CSCBL script is achieved as a result of a participatory design process with two practitioners (the main teacher and an assistant). Participatory Design is a field of research and an evolving practice among design professionals that has strong historical roots in the Scandinavian traditions (Gregory, 2003). Researchers in this field explore conditions for user participation in the design and introduction of computer-based systems at work (Kensing & Blomberg, 1998; Schuler & Namioka, 1993). PD methods enable the people destined to use technological solutions to be involved in their design. PD can lead to hybrid experiences that share attributes of both the workers' space (in this case the teachers from the high school) and the software professionals' space (researchers as technicians) (Muller & Kuhn, 1993).

In this study, we adopt PD as a method for the design of CSCBL scripts using 4SPPIces. 4SPPIces was the instrument for communicating with the practitioners. Although the use of the model was transparent for the teachers, it was used for defining a preliminary illustrative scenario to show the teachers the possibilities that ICT offers for education and encourage them to reflect about how could they apply these technologies in one of their practices. We followed an adaptation of the scenario-based approach design proposed by Carrol (Carrol, 2000).

Due to availability limitations of the teachers, two meetings were possible and most of the work was done via e-mail and telephone conversations. The 4SPPIces-based scenario was employed during the meetings for: (1) structuring the design process according to the aspects considered in the model, (2) guiding the decisions when defining the narrative of the CSCBL script and the educational materials needed for the activity and (3) identifying the requirements of the technological environment for its support. Therefore, the 4SPPIces-based scenario promoted and facilitated communication among the teachers as a support for discussing about how to enhance the Geography course activity so as to reach a CSCBL script adjusted to the teachers' circumstances, interests, needs and learning objectives.

Next section shows the resulting CSCBL script, including the information about the different phases, how each phase has been implemented and the associated materials. The actual materials exchanged with the teachers are listed and described in Tables A.1 y A.2 of the appendix.

The CSCBL script narrative, technological environment and materials

The script resulting is named "Discovering Barcelona!" and its **narrative** describes a learning flow composed of 4 phases: 1) *Assigning the districts*, in which each student individually answers a questionnaire about the different districts of the city, 2) *Discovering the district*, in which the students using handheld devices with GPS explore the district they have been assigned to; 3) *Reflect about your district and learn about other districts*, in which the students are asked to prepare and perform a presentation about the district they have visited, and 4) *Test your colleagues*, in which the students are asked to prepare some questions about the district visited to their colleagues. Only phases 2 and 3 are mandatory.

The **technological environment** designed for supporting the CSCBL script combines four technologies/applications: a Moodle platform (Dougiamas et al. 2004), Google Spreadsheet (Google Spreadsheet website), QuesTInSitu Application (Santos et al. 2011) with mobile devices and the Mscape (Stenton et al. 2007) application. Figure 2 shows a schema of the different phases and their supporting technologies. See also section A.II of the appendix for more information about the technological environment designed.

[FIGURE 2 goes here]

[**Figure 2** Schema of the technological environment generated for supporting the students' and teachers' tasks during the enactment of the CSCBL script.]

- **Moodle Platform:** provides the mechanisms for facilitating teachers and the students an overview of the complete learning flow and the description of tasks for each phase.
- **Google Spreadsheets:** to support the group formation.
- **QuesTInSitu and mobile devices:** a web-based application that enables the generation of questions that can be automatically corrected and to associate them to a geographical coordinate with GoogleMaps (Google Maps website). QuesTInSitu includes a functionality to create routes complemented with a monitoring system. Routes are sequences of geo-located questions created and organized by the user. The routes are visualized in a Google maps as a set of markers. The monitoring system provides information about the students'

evolution of these routes in real time. When a user answers a question the database of the system is updated and the marker associated to this question changes from green to red. The teachers can visualize the progress of the students along the route on real time by looking at the red and green markers. Clicking on the markers, the teacher can also know who answered the question and the score.

QuesTInSitu allows two types of mechanisms for answering the questions: (1) answering the questions online by accessing the application through a browser (Assessment in *virtual* situ) and (2) using a portable device to answer a question at the same geographical location to which the question is associated (Assessment in *real* situ). Since the exploratory activity requires different groups performing the activity simultaneously in different locations of the city, for this experiment we used the second option. Both the assessment in *real* situ and the monitoring functionalities are used in the *Discovering the District* phase.

- **Mscape:** is a mobile media platform for generating what is called a mediascape. Mediascapes are maps that associate a digital media file with a GPS position that allow triggering multimedia content based on the context, such as physical location. These maps can be installed in GPS mobile devices or PDAs. The GPS device senses their position of the user and throws the media file associated to this geographical coordinate. For the experiment, Mscape was used to complement QuesTInSitu to provide a more intuitive and integrated experience for the students. QuesTInSitu enables relating a question to a geographical coordinate, but does not integrate a module for detecting the actual position of the students in real time. Three mediascapes were created for the experiment. Since some of the districts in Barcelona do not have good GPS coverage and the GPS devices do not work properly in these areas, the Mscapes were created for the whole route only into two districts (Eixample and Les Corts) and in a part of the SantMartí route. For the rest of the districts the students were provided with a map indicating the location of the different questions.

The teachers also indicated as necessary to deliver some **materials** to the students as a complement for the activity:

- a dossier with the description of the different phases.

- a template to fill in during the route according to his/her role in the group.
- a map of the assigned area to the students to help them in following the route and to facilitate having a general overview of the district. For those districts with GPS coverage, the maps did not contain any information about the questions emplacement because the GPS served as a guide indicating where to answer the questions (Figure 3, bottom). In contrast, those groups without GPS coverage had the questions indicated in the map (Figure 3, top).

The result of this design process is a CSCBL script that combines four structured and interconnected collaborative activities (Pedagogical method, History) supported by a variety of technologies that enable coordinating groups of students (Participants) at the classroom, at home and across the city (Space). Within this structured activity flow, activities such the exploration with mobile phones, typically of an informal nature, become formal when integrated in the script with traditionally formal activities such as answering an online questionnaire.

[FIGURE 3 goes here]

[**Figure 3** Maps delivered to the students during the visit. On the top, an example a map delivered to the students assigned to the areas without GPS coverage. On the bottom, an example of a map delivered to the students assigned to areas with GPS coverage.]

Implementation of the phase *Assigning Districts*

The 34 potential students (P, *Number of participants*) were distributed into 6 groups of 5 or 6 people (PM, *Group characteristics*). Each group member was asked to answer individually a questionnaire about the different districts of Barcelona at home using their personal PC (S, *Location*). The objective was to define the students' profile with their initial knowledge from the city is and their main preferences with regard to one or other district (P, *Profile*). The information obtained from this questionnaire was used to assign the groups to a particular district associating them to an area that they did not already know, in order to maximize their potential learning, (P, *Profile dependent group formation*) as follows: when most of the group members fail the questions about a district, the group was assigned to this district. The groups in this phase were the groups for the following phase (I, *Events on PM-outcomes from phase to phase- and Events on P-groups in each phase-*).

In this phase, **Google Spreadsheets** was employed for the group formation. The pre-questionnaire for identifying the students' knowledge about the districts and their previous knowledge was created with the Google spreadsheets tool. According to the literature in CSCL, the script should be flexible enough for leading with unexpected events when enacted into a real setting (see section *Approaches towards the design of complex collaborative activities)*. In this phase, the main flexibility issues are captured by the *History* factor: the number of students per group can vary and also the number of students per group answering the first questionnaire about the district. Google Spreadsheets enabled visualizing in a simple table the answers of the different students and easily change the group organization. With this information the teacher assigned each group to a district: Sarrià (5 students), SantMartí (6), CiutatVella (6), Gràcia (5), Eixample (6) and Les Corts (6).

Implementation of the phase *Discovering the district*

This phase was based on the learning flow Collaborative Learning Flow Pattern (henceforth CLFP) Guiding Questions (PM, *Learning Flow and Activities*) (Hernández-Leo et al., 2010). The idea of this pattern is to provide the students with a list of questions that they should be capable of answering as they advance in the task. These questions were expected to help the student in focusing their attention on the important issues of the task. The questions were distributed and geo-located across 6 different districts in Barcelona forming 6 different routes: Sarrià, Gràcia, CiutatVella, SantMartí, Les Corts and l'Eixample (S, *6 mobile phones available = 6 districts*). This means that in the same phase there were 6 groups performing the exploratory activity simultaneously in 6 different spatial locations (P, students' *Location*). The students answered the questions along the route when arriving to the specific geo-located point. Each question had an associated feedback that guided the students to the next question and gave them hints about the urban and social characteristics of the area.

Each of the group members was assigned to a role as a means to assure an appropriate task distribution, to foster the individual responsibility, mutual support and positive interdependence. The roles agreed with the teachers were:

- Mobile Phone Manager: in charge of wearing the handheld device, read the questions to the rest of the group members and answer it according to the

whole group opinions.

- Guide: in charge of guiding the rest of the group through the streets with a map created for the different districts.
- Photographer: in charge of taking representative pictures justifying all the aspects specified by the teacher and uploading them to a web application specially developed for the experience.
- Question Helper: in charge of taking notes of the ideas and comments related with each of the questions of the route.
- Observer: in charge of annotating the main aspects and comments related with the characteristics of the district specified by the teacher such as the morphology of the streets, the number of parks or the public services available.

In this phase, the students used mobile smart phones Samsung Omnia I and II with QuesTInSitu and MScape.

Implementation of the phase *Reflect about the district*

In this phase the students prepared a presentation about the district they visited. They could use the notes, observations and pictures taken during the route. Each group had to present their work in the classroom to the rest of the students and deliver it to the teacher two weeks after the exploratory activity. The outcomes from the previous phase were used here as an input for preparing the presentation (PM, *Data flow*).

The students could use any tool to prepare their presentations.

Implementation of the phase *Test your colleagues*

Students could propose questions about their assigned district to their mates. Then, they could individually choose any of these questions and answer them as a self-assessment activity. Unfortunately, this phase, although was originally present in the script designed, was cancelled in the last-minute because of time limitations (coincided with the Spanish official period of high school examinations). Therefore, no data about this phase have been considered for the case study evaluation. For this phase it was planned to use the web questions functionality of QuesTInSitu.

In all phases the **Moodle[1] platform was employed to** provide means to visualize and manage the learning flow, the data flow and the students' groups (Figure 4). Task assignments were managed for the different groups via the credentials provided to the different users for accessing the Moodle. In this way, it was possible to store the activity of the students as individuals or as a group member.

[FIGURE 4 goes here]

[**Figure 4** Moodle course developed to provide teachers and students with an overview of the learning flow. This course was used to centralize the access to the rest of the applications used in the experiment to support the activities.]

Evaluation methodology and analytical strategies

The main goal of this case study is to evaluate whether a CSCBL script that considers the 4SPPIces factors is useful for a particular context. The enactment of the CSCBL script involves an authentic learning situation, which includes many factors such as contextual issues, characteristics of students and educators, the achievement of the educational benefits, and the impact of software tools. We concentrate on two main focuses for analyzing the experiment:

- **Focus I relates to the innovation and added value of the CSCBL script**; i.e. whether the CSCBL script solves the limitations of the previous practices covering the main learning objectives highlighted by the teacher.
- **Focus II relates to the appropriateness and suitability of the collaborative technological environment associated to the CSCBL script for supporting the students' and teachers' tasks**. The strengths and limitations experimented by both teachers and students during the enactment are also considered in this point for further improvements.

All the data are aggregated and analytically compared using a mixed evaluation method (Martínez-Monés, 2003; Frechtling & Sharp, 1997). This technique is especially interesting for the experiments that put into practice new technological usages into an authentic learning situation (Johnson et al. 2007; Maxwell & Loomis, 2003). Rather than confirming or rejecting a research hypothesis, the aim of this evaluation methodology is to identify tendencies in the aforementioned

[1] http://gti-learning.upf.edu/moodle/

issues in this particular learning context. To capture information from the context we mix quantitative data coming from closed questions and event log files generated automatically by the mobile phones, with qualitative data such as open-ended questions and first-hand observations. The quantitative data are useful for showing trends, and the qualitative data provide an in-depth understanding of the CSCBL script enactment (Adams et al, 2008).

Mixed methods are applied into three phases: (1) Definition of a scheme of categories, (2) data collection and (3) Analysis and interpretation.

(1) Definition of a scheme of categories

The definition of categories can be done empirically (according to past experiments) or theoretically (according to the specific objectives of the experiment). We followed the second approach. New categories can emerge throughout the study, which means that this initial definition can vary (Martínez-Monés et al. 2003).

To guide the definition of this scheme of categories, for each of the focus of analysis we define different issues to be analyzed with their associated information questions. The issues and associated information questions related with the **first evaluation focus** (I) are:

- **Issue I.1**: *Added value of the CSCBL script in terms of learning benefits related with the course contents, collaborative learning and motivational aspects*. The information questions related to this issue are: (1) Which is the added value of the CSCBL script in terms of learning benefits related with the course contents? (2) Does the mixture of activities integrated into the same learning setting support students' reflection about the explored environment and the concepts worked in class? (3) Does the CSCBL script and its grouping and task distribution policies support the acquisition and practice of communicative and collaborative skills and (4) Does the script foster the students' motivation?
- **Issue I. 2:** *Innovative aspects with respect to previous editions*. One information question is related to this issue: (1) Which are the aspects that make the activity innovative with respect to previous editions?

The issues and associated information questions related with the **second evaluation focus** (II) are:

- **Issue II.1**: *Successful aspects of the technology designed for supporting the*

teachers' and students tasks'. The information questions related to this issue are: (1) Is the combination of the technologies proposed appropriate for supporting teachers' orchestration tasks? and (2) Is the combination of technologies proposed appropriate for supporting students' tasks?

- **Issue II.2:** *Limitations and suggested improvements of the technology designed for supporting the teachers' and students task.* The information question related to this issue is: (3) Which are the limitations and suggested improvements of the technological collaborative environment for supporting teachers' and students' tasks?

(2) Data collection

The data collection consists in collecting qualitative and quantitative data using different techniques such as questionnaires, log files, observations, video recordings... Figure 5 shows the data extracted along the experiment and the technique employed.

The [Students Outcomes] was a questionnaire with open and closed questions used to extract information about the knowledge of the students about the city before the experiment. The [Q-st-route], [Q-t-route], [Q-st-final] and [Q-t-final] included close and open questions about the students' and teachers' perceptions of phase 2 and of the whole activity, respectively. Finally, the [Videos-route] and [Videos-presentations] obtained in phases 2 and 3 gave qualitative information about the behaviour of the students and teachers along the whole activity. The marks and contents of the students' [Presentations] were used as a quantitative and qualitative data to have an overview of the knowledge acquired about the city. Finally, the [Observations] taken by different researchers in phase 2 were used as qualitative information related with the technology usage.

[FIGURE 5 goes here]

[**Figure 5** Data gathered extracted along the experiment.]

(3) Analysis and interpretation

According to the mixed evaluation method applied, the emphasis is more on the qualitative than in the quantitative analysis. For interpreting all these data, we use a method called "triangulation" (Guba, 1981; Guba and Lincoln, 1994). This method consists in reinforcing each of the interpretations extracted through a comparative analysis of evidence provided from different sources. That is, to

analyse each conclusion from a different perspective in order to have several confirmations supported by both qualitative and quantitative data.

The final marks of the students' projects and the results of the closed questions in the questionnaires constitute the quantitative data of the experiment and were analyzed using a Spreadsheet. To structure and triangulate the qualitative data we used Nud*Ist (Gahan & Hannibal, 1998). This application enables relating the data from different sources to the different categories defined in the first phase. The result is a project in which the data coming from the different sources is categorized according to the research objectives.

Finally, both the quantitative and qualitative data are organized in tables according to the different information questions. This organization facilitates deriving a list of partial results for the different issues under study supported by different data sources (Tables A.6 and A.7 of the Appendix). These partial results are related and organized into the list of findings in Table 1. Next section presents and discusses this table. The final process of extracting conclusions was discussed and analyzed with two researchers.

Both the original data employed for the evaluation as well as the Nud*Ist project created for the experiment with the list of categories defined can be found in the appendix.

[TABLE 1 goes here]

[Table 1 Summary of findings of the empirical study**]**

Results and discussion

In order to facilitate the readability of the findings we have organized them according with the two focus of study introduced in the previous section. The results are presented as follows:

- **Bold text** is used for emphasizing the main findings related with the issues under analysis in each focus.
- "Text between quotations" is used to indicate the sentences and comments of the students and/or teachers.

Focus I: Innovation and added value of the CSCBL script

The findings of the first focus of study as well as the partial results that support them are summarized in table A.6 of the Appendix.

The **first finding** (I.1 in table 1) indicates that the **CSCBL script copes successfully with the limitations detected by the teachers in previous editions of the experience and entails new learning benefits**.

Different partial results supported by qualitative and quantitative data evidence this finding. First, observations and comments of the teachers and students after the exploratory experience show that the experience promotes students' autonomy and active learning [Q-st-route, Q-t-route, Observations]. Second, students' and teachers' comments at the end of the experience suggest that the usage of mobile phones and GPS is perceived as an opportunity to practice and enhance technological and orientations skills not commonly worked in the traditional activities [Q-st-route, Q-t-route]. Third, teachers and students agree with the idea that using mobile phones and automatic assessment functionalities help on focusing the attention to the environment and on better retaining and reflecting about the contents. And fourth, teachers highlight that the activity, compared with previous experiences, enables learning about different areas of the city with new important benefits. One teacher comments the added values of the experience: "Using these tools – ICT - in an urban environment and having the possibility of learning about more districts of the city" [Observations]. This evidence is also supported by the results of a closed question in which students are asked whether they learn more using the mobile in situ than filling a dossier or doing an exam. 28/34 (82%) chose the mobiles, 4/34 (12%) the dossier and (2/34, 6%) did not answer the question [Q-st-route]. Also, 33/34 (97%) of the students indicated after the whole experience that the activity helped them to learn new concepts about the districts. 23/34 students (68%) valued their feeling of learning with 4 points over 5 in a likert scale from 1 to 5 [Q-st-final].

These partial results indicate that considering the S and PM factors promotes innovative usages of technologies such as GPS and mobile phones that entail new learning benefits for the students.

The **second finding** (I.2 in table 1) shows that **structured group activities, the role-distribution during the exploratory phase as well as the pre-test district assignment policy promote the collaboration and cooperation between students by enhancing teamwork skills.**

Different partial results support this finding. First, the students' comments and observations by experts suggest that structuring the group activities with a explicit

role-distribution helps on the task distribution, which promotes an active participation of the whole group members, makes the activity more dynamic and promotes discussions fostering the students' communicative skills and reinforcing cooperation [Q-st-route, Q-st-final, Q-t-route, Q-t-final, Videos-route]. Some students explicitly appreciate the role distribution as a mechanism to make all group members feel that all are participating and cooperating and are conscious of the positive interdependence among group members that this generates [Q-st-route, Q-st-final]. Also, a quantitative result reinforces these qualitatative evidences showing that 34/34 (100%) of the students answered in a closed question of the final questionnaire that it was helpful working in groups. Second, students' answers support a partial result that indicates that organizing the exploratory phase through a sequence of questions and with feedback guide the students' along the activity at the same time that promotes debates that make students reflect and look for agreement enhancing cooperation [Q-st-final]. The guidance of the feedback is corroborated by yes/no question of the questionnaire about the route. 33/34 (97%) of the students indicated that the feedback helped them to know how to continue in the activity and their progress on it. Third, working directly in contact with the environment enhances student's interactions with people in the city making them to practice their communicative and social skills in situations they are not used to [Observations]. Finally, as a fourth partial result, the transcriptions of the video presentations indicate that all group members in all the work teams contributed and participated in the final presentation.

This finding shows that considering the facets of the PM and P factors enable conceiving complex collaborative leaning tasks that promotes students' interactions that help them in promoting collaborative skills.

The **third finding** (I.3 in table 1) indicates that the CSCBL **script is a motivational and innovative activity for students and teachers compared with previous experiences**.

First, students use positive adjectives such as different, interactive, fun, dynamic and interesting for describing the activity. Student's comments about the exploratory activity support this partial result: "I liked the activity because it is an activity very different from the rest (of the activities out of the classroom)" [Q-st-route] or "The experience changed the way in which we are used to do school

trips" [Q-st-route]. When referring to the whole experience they say: "It (the experience) has been more interesting than the 'typical museum visit' and it has been more fun" [Q-st-final]. Also quantitative data reinforces this result. Students punctuated with high ratings the Discovering Barcelona phase: 24/34 (71%) of the students qualified it with 4 over 5 and 10/34 (29%) with 5 over 5. 34/34 (100%) of the students and the two teachers would repeat the activity on another course for learning about another district [Q-st-route, Q-t-route]. Second, students enjoyed working in groups and highlight this as one of the most positive and innovative aspects of the activity. For example, when a student is asked if he prefers this activity compared with similar experiences he comments: "Yes. This activity is better and more fun compared to other activities (such as going to a museum). Moreover, this activity allows us to work in groups in a very fun way" [Q-st-final]. Finally, the third partial result indicates that students perceived the CSCBL script as an innovative experience compared with previous similar ones also because of the use of technology and, in particular, mobile phones. Both, students and teachers, see the use of ICT as one of the aspects that make the experience innovative and different from others. Students see that working with mobile and GPS is an original and motivating experience and stress the fact that it is not common to use technological devices in educational activities [Q-st-final]. This is also reinforced by a quantitative result. In a question asking about the experience as a whole, 31/31 students (3 students did not attended to the class that day) say that they prefer this activity compared with similar ones [Q-st-final].

This finding indicates that considering the 4SPPIces factor has enabled to conceive an activity that proposes innovative usages of technologies with educational intentions. The interrelation between the different factors enables identifying which technological support is better to use for the educational purposes.

The fourth **finding** (I.4 in table 1) indicates that the **integration of the exploratory activity with the presentation task into the same learning setting promotes students' reflection about the contents studied in class and in other courses and is seen by the teachers as a condition necessary to provide a complete evaluation of the activity**.

Different partial results support this finding. First, observations by experts show how students, during the route, made references to concepts and topics worked in

class [Observations]. Second, observations taken during the students' presentations and comments by the teachers show the importance of integrating exploratory with more reflective activities into the same learning setting. Third, the observations taken from the videos of the presentations and their contents show that the students used multiple sources of information to complement their explorative experience [Presentations, Videos-presentation]. And fourth, teachers stress the idea that the visit and the presentation activities are complementary [Observations] and a good mechanism to "apply in a concrete way the contents explained in class" [Q-t-route]. Therefore, all these partial results show how both teachers and students perceive the different phases of the activities as a unique learning setting.

Finally, this finding evidences the importance of the Data flow facet of the PM factor. This facet and their relation with the other factors facets in the model (all captured by the History factor) emphasizes on the importance of creating a technological environment in which the different activities are interrelated.

Focus II: Suitability of the technological environment for supporting the CSCBL script

The findings of the second focus of study as well as the partial results that support them are also summarized in table A.7 of the Appendix.

The **first finding** (II.1 in table 1) shows that **the mobile and GPS devices combined with the monitoring functionalities included in QuesTInSitu and complemented with a Moodle platform are a good support for teachers to control the groups' progress during the whole experience, especially during the Discovering Barcelona phase.** Different partial results support this finding.

First, the technology designed reduces the organizational teachers' efforts during the exploratory phase. The exploratory activity is the activity that entails the most complexity in terms of orchestration. However, the observations and comments by the teacher during this particular phase indicate that they could easily and successfully follow what the students were doing on runtime while discussing about the answers given by the different groups [Observations]. Second, teachers value very positively the Monitoring functionality. On the one hand, they selected this functionality as the best one of the system and qualify its intuitiveness with the highest mark in a likert scale from 1 to 5 [Q-t-route]. And third, teachers

describe the whole technological environment (applications, servers, webs…) in relation with the functionalities provided and the organizational and management benefits that they carry as very well designed and "practical, functional, organized, clear, easy and comprehensive" [Q-t-route].

This finding indicates that the system successfully hide the complexity of the orchestration tasks required. This fact also indicates that, considering the History factor helps on conceiving an orchestration system able of managing all the important aspects in the rest of the factors and that influence the activity enactment.

The **second finding** (II.2 in table 1) shows that **the mobile devices completed with a map as well as the questions feedback are a successful mechanism to organize, structure, support and guide the student's actions during the exploratory tasks**.

First, students and teachers highlight that mobile devices and the automatic assessment and feedback mechanism are easy to use, useful and a structured and clear way to guide the activity. The notes by the experts, which indicate that all groups used the feedback messages from the mobile to know where to go in the next activity, support this partial result [Observations, Q-t-final, Q-st-final]. Moreover, 33/34 (97%) students indicated that the feedback helps them to know how to continue in the activity and their progress on it. Second, the use of the GPS and maps complement the guidance provided by the feedback. First, the comments of the 10 students that performed the activity with GPS (groups Eixample and Les Corts) indicate that they felt well guided during the route. Furthermore, when the students of these groups are asked whether they could have performed the activity without the map, 6 (out of 10 because 4 did not answered the question) answered affirmatively. On the contrary, the students that did the activity without the GPS (groups Gràcia, Sarria and CiutatVella), although they think that the GPS is not necessary to perform the activity, their comments indicate that they had difficulties on finding some locations of the route and would find useful to use the GPS. For example, one students says: "I think that the GPS would have been useful because sometimes, when answering the questions and listening to the clues for the next question we were confused because we were not correctly located" [Q-st-final_NoGPS]. Finally, those students that used the GPS during half of the route (group Sant Martí), when they were asked to

compare the two situations they remarked that preferred using the GPS because it is faster, easier and practical [Q-st-final_GPS]. Therefore, this comparison among groups indicates that both the GPS and the map complemented the feedback of the questions to guide the students along the route.

This finding shows the importance of considering the 4SPPIces factors together. The relationships between the PM, the S and the P captured by the I indicates that to structure the activity only with technology is not enough and that other complementary materials are needed.

Finally, the **third finding** (3 in table 1) **shows that the technology employed was usable and appropriate for the experience for both students and teachers**.

First, students prefer using mobile phones for the exploratory activity than other traditional techniques such as filling a dossier or doing an exam. Most of the students comment that mobile phones allow them to be directly in contact with the environment, which makes it easier to answer the questions and to pay attention to the details [Q-st-route]. Moreover, when they are asked to choose about using a mobile phone, filling a dossier or doing an exam in class 32/34 (94%) answered that they preferred the mobile. Only two students indicated that they preferred a dossier. Second, the students successfully adopted the technology developed specially for the exploratory experience (the QuesTInSitu application). The observations by the experts indicate that students easily managed the QuesTInSitu application [Observations]. Also a quantitative result corroborates this partial result: 33/34 students (one student forgot to answer this question) answered that this application was easy-to-use. Finally, the third partial result indicates that some problems related with the GPS applications of the mobile phones as well as some functionalities of the QuesTInSitu application should be considered for future editions of the activity. On the one hand, the observations taken by the experts during the exploratory phase and the comments from the students evidence that the GPS failed in particular points of the route with lower coverage [Observations, Q-st-route]. On the other hand, teachers suggest improving the Monitoring functionality of the QuesTInSitu application adding an audiovisual module to see the students' action on runtime [Q-t-route].

All in all, this last finding shows that analyzing and understanding the educational necessities structuring the activity according to the 4SPPIces factors is

essential to indentify the requirements of a technological environment for supporting collaborative learning scripting practices combining spatial locations successfully.

Conclusions and future work

This work is focused on presenting an illustrative case study in which a 4SPPIces-based collaborative learning script blending spaces has been enacted into a real situation. The actual context was an authentic fieldwork activity framed in a geography course of a secondary school. Considering the 4SPPIces factors was useful to design a new script overcoming the limitations of previous editions of the activity in a way that the following aspects highlighted by the teachers were addressed: 1) including the visit of more than one unique district of Barcelona city, 2) introducing a collaborative component in the activity and 3) introducing a technological resources as a support for the activity.

Two aspects (or focuses of study) of the CSCBL script enactment have been analysed in this case study: (1) whether the script is innovative enough to solve the limitations of previous practices maintaining the learning objectives and (2) whether the technological system developed is appropriate for supporting the students' and teachers' tasks defined in the script.

The results of this analysis, fruit of an extensive work of data analysis combining quantitative and qualitative sources, show that the CSCBL script designed copes with the three requirements imposed by the teachers. These results enable extracting concluding remarks with regard to the effects of considering the 4SPPIces factors in the design of the script.

First, to consider the *Space* factor has proved to be a good mechanism for extending the previous editions of the activity involving the visit of new areas of the city. Taking into account the spatial locations where the activity occurs has had an impact on the selection of the technological support to be used, mobile devices in this case. Moreover, the *Space* factor in relation to the number of *Participants* has derived in structuring the *Pedagogical Method* around the visit and comparison of 6 districts of the city. Students directly explore the urbanism and geo-sociological characteristics of one district and learnt about other districts from the presentations of their colleagues.

Second, the structure of the CSCBL script and the group management based on

a role-distribution inspired by the relation between the *Pedagogical method* and the *Participants* factors introduced a collaborative component to the activity. The combination of an explorative-type structured activity with a final presentation in class promoted the active participation of all group members making them discuss, argue and think critically by enhancing collaborative and communicative skills and promoting cooperation. Also, this combination and interrelation of more formal and informal types of activities inspired by the *History* factor has shown that helps teachers on having a complete overview of the concepts acquired during the whole activity.

And third, the interrelation and dependencies between the different factors captured by the *History* factor has lead to propose an innovative combination of technologies that has been easily adopted by both teachers and students. For the students, technology made the experience more dynamic, original and fun, which had a direct impact on their motivation and, therefore, on their knowledge acquisition. At the same time, findings suggest that using technological support for the activities also entailed other learning benefits for the students such as to practice their technological and orientation skills. For the teachers, the combination of technologies with other materials such as (maps, guides…) supported them in organizing and structuring the whole activity. Even those activities that required a complex management on real time were carried out successfully. Finally, implementing a technological environment based on the Learning flow facet of the PM factor helped in generating on teachers and students the perception of an activity not composed by disconnected phases and activities but as a complete and integrated set of activities.

In conclusion, and based on the findings of the case study, we can state that 4SPPIces has been a useful framework to design a meaningful CSCBL script involving the teachers that successfully extends an actual geography activity. The encouraging results of this CSCBL script evidence the benefits and positive effects of considering the 4SPPIces factors for transforming an actual activity into an innovative collaborative learning activity in the blend, keeping the balance between technology and education.

The 4SPPIces factors have also been considered in other cases in different contexts. In particular, two other CSCBL scripts proposed to support first-engineering students in discovering the University Campus have been generated

according to the 4SPPIces factors. One of these scripts has been already carried out and evaluated (Pérez-Sanagustín et al., 2011) while the other, based on a preliminary proof-of concept (de-la-Fuente-Valentín et al., 2010), is still under analysis. We are also comparing the results of these case studies towards a cross-case analysis, shaped as a multicase study in order to achieve contrasted evidences about the usefulness of the 4SPPIces factors. Finally, with the aim of guiding the design of CSCBL scripts and facilitate the computer-supported collaboration between practitioners, we have developed a web-based application based on 4SPPIces that we expect to test with real users.

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Table 1. Summary of findings of the empirical study.

Summary of findings
Focus I. Innovation and added value of the CSCBL script
I.1. The CSCBL script copes successfully with the limitations detected by the teachers in previous editions: students learn about sociological and urbanism characteristics of 6 different districts of Barcelona working in groups and using technology.
I.2. The CSCBL script promotes the collaboration and cooperation between students and developing teamwork skills.
I.3. The CSCBL script is a motivating experience that promotes the active participation of the students and is innovative compared with similar experiences because of the use of technology.
I.4. Students and teachers feel comfortable with the pre-test district assignments policy and role-distribution as a successful mechanism to structure collaboration.
I.5. Combining exploratory activities with the presentation work into an integrated learning setting promotes students' reflection about concepts acquired in class and in other courses. Teachers also consider this integration necessary to provide a complete evaluation of the activity.
Focus II. Appropriateness and suitability of the collaborative technological environment associated to the CSCBL script for supporting the students' and teachers' tasks
II.1. The mobile and GPS devices combined with the monitoring functionalities included in QuesTInSitu and the Moodle platform provide teachers with a support to follow students' activity.
II.2. Mobile devices complemented with a map as well as the questions are a successful mechanism to organize, structure, support and guide the actions during the exploratory phase.
II.3. The technology employed in the CSCBL script is usable appropriate for the experience.

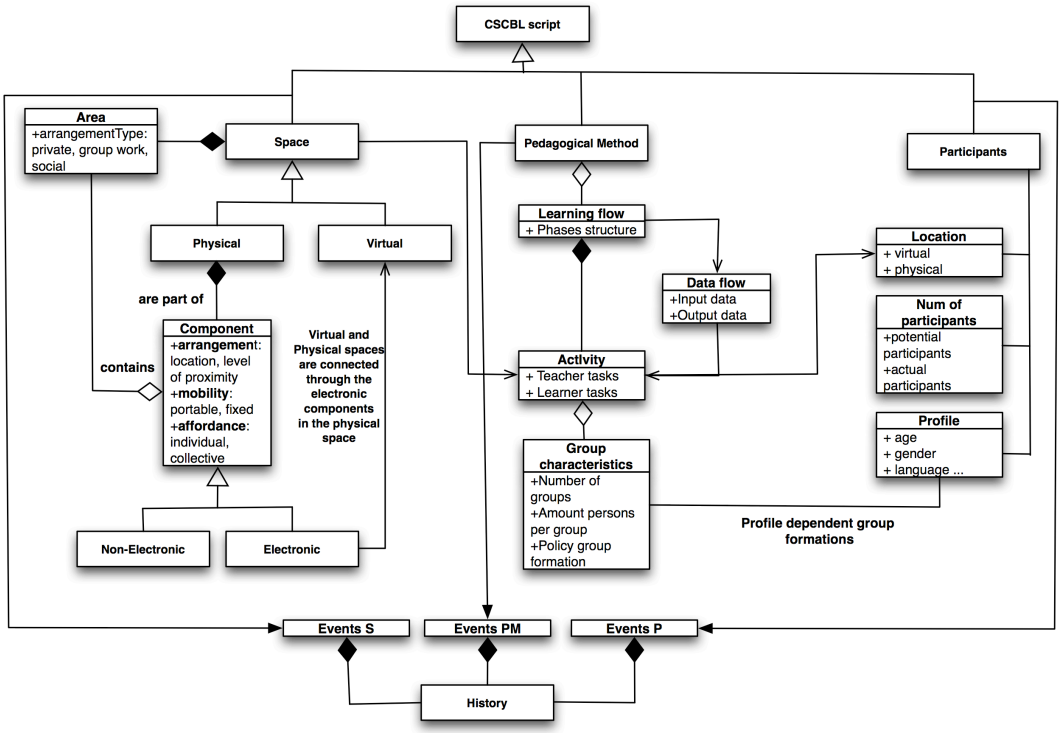

Figure 1 4SPPIces model. Factors and facets to be considered in the design of CSCBL scripts and of the technological environment for supporting their enactment.

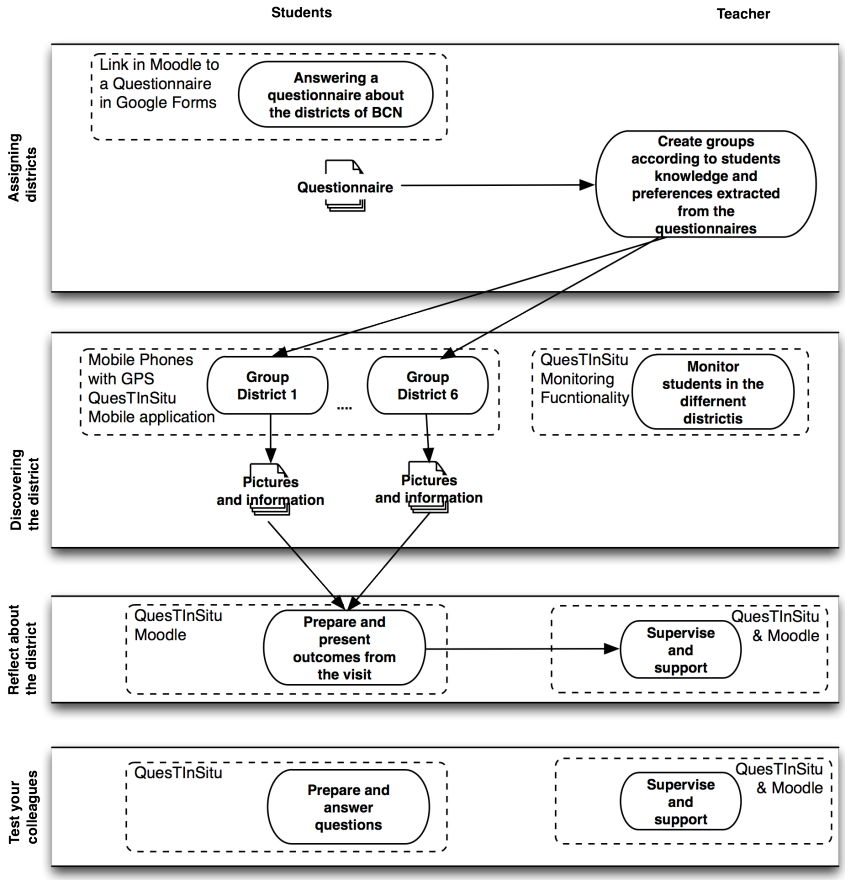

Figure 2 Schema of the technological environment generated for supporting the students' and teachers' tasks during the enactment of the CSCBL script.

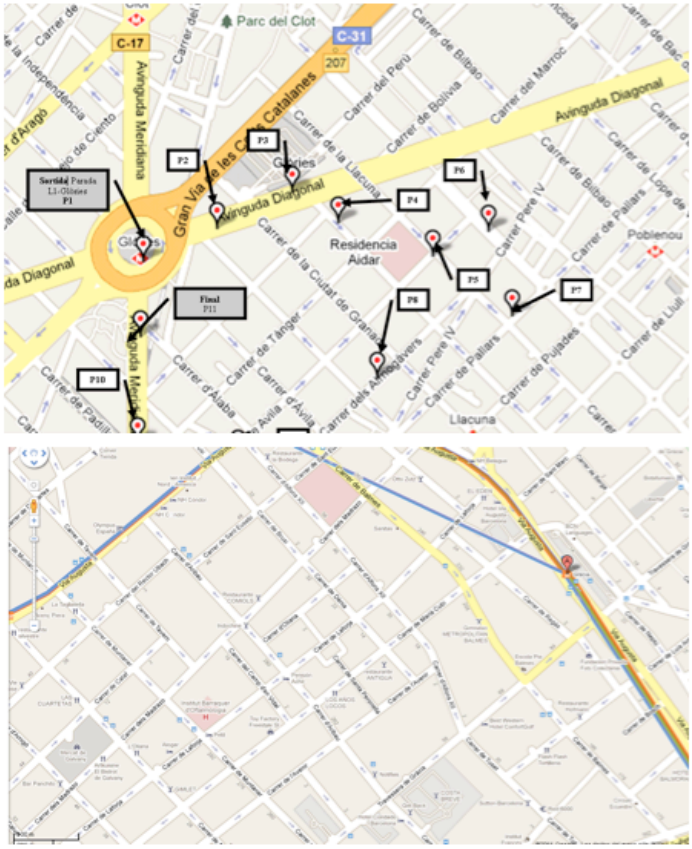

Figure 3 Maps delivered to the students during the visit. On the top, an example a map delivered to the students assigned to the areas without GPS coverage. On the bottom, an example of a map delivered to the students assigned to areas with GPS coverage.

Figure 4 Moodle course developed to provide teachers and students with an overview of the learning flow. This course was used to centralize the access to the rest of the applications used in the experiment to support the activities.

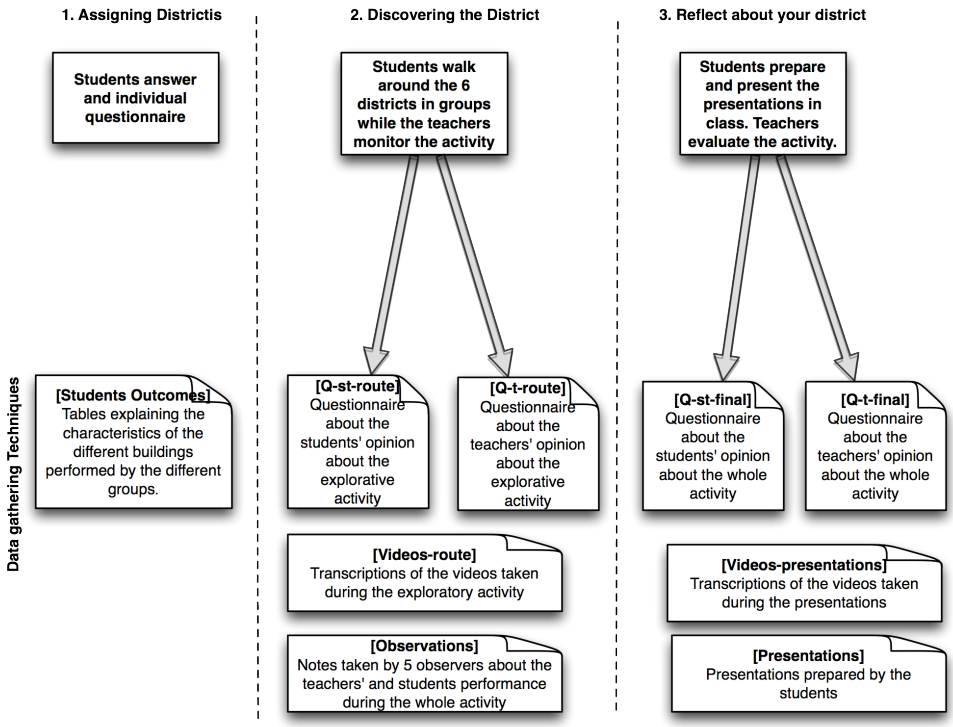

Figure 5 Data gathered extracted along the experiment.