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System Orchestration Support for a Collaborative Blended Learning Flow

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Abstract. Portable and interactive technologies are changing the nature of collaborative learning practices and open up new possibilities for Computer Supported Collaborative Learning (CSCL). Now, activities occurring in and beyond the classroom can be combined and integrated leading to a new type of complex collaborative blended learning scenarios. However, to organize and structure these scenarios is challenging and represent a workload for practitioners, which hinder the adoption of these technology-enhanced practices. As an approach to alleviate this workload, this paper proposes a proof of concept of a technological solution to overcome the limitations detected in an analysis of an actual collaborative blended learning experiment carried out in a previous study. The solution consists on a Unit of Learning suitable to be instantiated with IMS Learning Design and complemented by a Generic Service Integration system. This chapter also discusses to which extent the proposed solution covers the limitations detected in the previous study and how useful could be for reducing the orchestration effort in future experiences.

1 Introduction

Portable devices have impacted multiple aspects of our everyday life. In education, researchers and practitioners see the potential of this technology as a chance for expanding current educational scenarios and exploring innovative learning methodologies [15]. Particularly in the area of Computer Supported Collaborative Learning (CSCL), the introduction of portable devices opens up a new debate about how this discipline is going to evolve [22].

Significant research effort has been devoted to introduce portable devices in learning activities and to understand how they might enhance current educational settings. Theoretical studies such as the one by Spikol et al. [25] or by Sharples et al. [24] evidence the interest on these new types of learning practices. The first one provides designers with a framework to tackle the challenges of designing for innovative mobile learning activities, while the second one proposes a model to analyze these innovative practices.

From a more experimental perspective, some works have started to explore the benefits of mobile and content delivery capabilities of this technology to generate learning settings enabling learners to work and collaborate at different spatial locations beyond the class. For example, Facer et al. propose a mobile gaming experience in which children are invited to understand the animal behavior in a savanna in direct physical interaction with this space [16]. The findings of this study show that this innovative experiment increased the self-motivation of children. Another work by Ruchter et al. describes an experiment using mobile computers as a guide for supporting environmental learning [23]. The results show that using these computers as mobile guides can lead to an increase in knowledge about the natural environment and an increase in students' motivation to engage in the educational environmental activities.

All these studies introduce a new concept of learning in which activities are no longer limited to the classroom space. A study by Park et al. states that "mobile learning activities could provide a better learning experience by establishing the conditions for optimal flow" [20]. This idea relates with the CSCL concept of orchestration. Orchestration is defined as the process of structuring and coordinating the actions of the course participants (the learning flows) for achieving potential effective learning outcomes [9]. According to Roschelle and Pea, "learning content's performance is optimized when it is orchestrated with a pedagogical sense" [22].

One of the proposals to organize and computationally support these learning flows is the so-called collaboration "scripts" [9, 12, 17, 18]. Scripts are based on the idea that free collaboration does not always produce learning. The rationale of these scripts is to structure collaborative learning processes in order to trigger group interactions that may be rare in free collaboration. When these interactions are technologically mediated they are called Computer Supported Collaborative Learning Scripts (or CSCL scripts). CSCL scripts manage resources and deliverables, define roles and phases and enable specific interaction in order to guide collaborative processes for producing situations of effective learning [9] by facilitating and reducing the coordination efforts of teacher and students [10, 11, 28, 29].

However, when these scripts combine activities supported by portable devices with activities taking place at different spatial locations, the orchestration process becomes more complex. In such as type of scenarios it becomes particularly challenging tracking students' progress [21]. These challenges hinder the establishment of the relations within activities and make the management of the collaborative learning flow more difficult. As a consequence, the orchestration of collaborative learning flows translates into an increase in the teaching staff workload.

The results of a previous work carried out by the authors of this chapter in an actual educational context evidence this workload [22]. The work presents a case study of a collaborative blended learning experience that combines mobile-based activities with in-class sessions. Despite the encouraging results, the enactment of these types of learning settings imposes a significant workload on the teaching staff. As a consequence, one of the conclusions of the study proposes automating some aspects of the enactment for future editions of the course.

The work presented in this chapter is based on the above-mentioned previous experiment. The goal is to present the proof of concept of a technological setting to automate some of the orchestration tasks of this learning flow. As a consequence, the teaching staff effort is expected to be reduced facilitating the replication of the course flow with a reasonable cost in future editions. With this aim, we created a scripted learning flow implemented in a Unit of Learning (henceforth simply UoL) for orchestrating the activities and automating management duties. The UoL is compliant with IMS Learning Design (IMS LD) [14] and extended with Generic Service Integration (GSI) [8]. As a conclusion, we discuss to which extend these technologies can overcome with the limitations detected and how useful might be in similar situations.

The rest of the chapter is organized as follows: Section 2 describes the experimental study in which this work is based on, gives an overview of the results obtained and exposes the limitations detected in the orchestration process. Section 3 describes the technological solution conceived to automate the orchestration process of this scenario. Section 4 presents the results of a simulation of the scripted flow proposed and discusses how this solution is envisaged to solve the limitations detected in the previous study and help reducing teaching staff workload on similar experiences. Finally, Section 5 presents the conclusions of this work and the future work lines.

2 Description of a Previous Experimental Study

This section is divided into three parts. First, the learning experiment carried out in a previous work by the authors of this chapter at the Universitat Pompeu Fabra (Barcelona, Spain) is presented [22]. Second, an overview of the main results obtained from the experiment is given. And third, the final subsection identifies the limitations regarding the orchestration process.

2.1 Description of the Experiment: Meeting the Campus Together

The CSCL experience was carried out with 74 first -year ICT engineering students enrolled in a mandatory course called Introduction to Information and Communication Technologies. The aim of the course is to give a global vision of the University and its resources, and an introduction to the professional world of ICT industry. The CSCL activity started the first day of the 2009-2010 academic years and continued during the next two weeks. The scenario was structured into three different phases following the learning flow defined by the Jigsaw Collaborative Learning Flow Pattern (CLFP) [1, 13].

The first phase consisted in an individual exploration of the campus. We named this phase “Discovering the Campus”. To support this activity 46 Near Field Communication (henceforth NFC) tags were distributed around the 5 campus's buildings. These tags contained information about the place in which they were located. Students were equipped with NOKIA (N6131, N6212) mobile phones, which included an embedded Radio Frequency IDentification (RFID) reader for accessing the information stored in the tags. Students had 30 minutes to freely explore the campus. All the information regarding the sequence of tags accessed by each student was stored into a log file. After the visit, students had to fill in a Google Forms questionnaire indicating which buildings had visited and which seemed to them the most interesting.

The second phase was called “Explain the campus”. In this phase, students were grouped in “Building's Expert groups”. Each expert group was associated to one of the 5 campus buildings and was composed by 4 or 5 members randomly chosen from the students with similar building expertise level. To define the students' building expertise the teachers considered two sources of information: (1) the log files obtained during the exploration and (2) the answers to the Google Form questionnaire. Depending on the places of the campus visited (registered in the log files) and the preferences about the different buildings (indicated in the questionnaire) there were defined as experts in one or another building. The activity for these teams was to create a presentation explaining the main characteristics of the building assigned and upload it to the Moodle Platform of the University (henceforth Moodle).

Finally, the third phase was called “Reflect about the campus”. For this activity, the teachers uploaded all the presentations from the previous phase to Moodle. Students had to access and review all the presentations and answer an individual test including questions about the whole campus. This last activity was carried out in a 25 minutes session in a classroom with PCs.

2.2 Overview of the Results of the Experiment

The results of the experiment show that the activity enacted was meaningful in terms of educational and motivational benefits. First, the results indicate that using mobile technologies in combination of other computational tools is a good mechanism to integrate all the activities into a unique learning setting that facilitates the students discovering the campus. Second, introducing an exploratory activity with mobile phones is shown a good way to foster the motivation of the students with regard to their studies, engineering research and teaching activities. And third, results show that the actual technology used during the activity was easily adopted and highly accepted by students and teachers.

Comments of teacher A at the end of the activity summarizes the aforementioned learning benefits and motivates its repetition in future courses: “*1. The activities are more significant to them (they experience the services of the University vs. they just hear about the services). 2. Students are active in the whole activity. Also, thanks to working physically with what they are learning, they have the opportunity to discuss with other students the buildings/services of their interest, to discover other buildings/services by explanations of their own classmates, etc. 3. Students make use of ICT technologies that they will be learning in their studies they are just starting (again enhances the significance of the activity)*”.

Here we have summarized the main outcomes of the activity, since the main focus of this study is to propose alternative solutions to the limitations identified during the orchestration of the activity, which are presented in the next subsection. More details about the data of the experiment underlying these results are given in [22].

2.3 Limitations on the Orchestration Tasks

Two teachers and one researcher carried out all the orchestration processes of the case study. The activity was technologically supported (NFC tags, mobile phones, Moodle) but there was no system that automatically integrated the whole process. This translated into some of the orchestrations tasks being done by hand. In what follows we present a detailed explanation of teacher tasks in each phase.

The task for the teachers in the first phase was to store the log files once the students finish the visit of the campus. Due to the number of students and the number of available devices, some of the students had to share a device for the visit. To identify which data log belonged to which student, teachers annotated the time when a device was given to a student or pair of students. This information was used later to make the correspondence between the log files and each of the students participating in the experiment. The files were uploaded to a computer via Bluetooth connection.

For the second phase, teachers had to form the building's expert groups. As explained before, the expertise was measured taking into account the number of tags per building visited by each student and the preferences indicated in the questionnaire. This was the most complex and time-consuming task. As the teacher B commented after the experiment: “The most time demanding and difficult part of the activity was to organize the groups depending on the students’ activity registered in the log files and the preferences answered in the questionnaires”.

First, the teachers manually analyzed all the log files created during the visit. Due to the number of students (74) this part was very time consuming and the process had to be reviewed three times by the two different teachers and a researcher to avoid errors. The teacher calculated an amount of 3 hours invested in this task.

Second, in the analysis of the questionnaire answered after the visit, the building recommended by the student was taken as the preferred one. This was carried out approximately in 4 hours.

Besides, the students were divided into two groups corresponding to the regular lecturing sessions. For the experiment, students from both groups were randomly mixed. Combining people from these groups also posed some problems. On one hand, students could not contact easily their classmates because they did not meet face to face in the classroom. On the other hand, because the activity took place during the first two weeks of the course, there were students dropping out the course before the final presentation so some groups had to be rearranged. The teaching staff using e-mail for communication carried on all these group adjustments.

The comments of the teachers after the experiment evidence the complexity and limitation of this orchestration tasks. For instance, one of the teachers of the course highlights the group formation and communication as some of the most demanding issues: “*Once the whole activity was set-up, I think it was more a* *matter of complexity than of difficulty. The logistics was the more demanding issue: creating groups, informing students about the groups, orchestrating their tasks depending on the groups, managing and analyzing their outcomes in order to propose them the following tasks, managing their outcomes in order to facilitate the assessment of their learning, etc" [Teacher A]. The other teacher stresses the need of an automatic tool facilitating the group formation: "We did not use any tool for creating the groups. It would have been very useful to have an automatic system to analyze the logs and the response to the questionnaires to create the groups*" [Teacher B].

In the third phase, the task of the teachers consisted in uploading the students' presentations to a public repository in Moodle and making students to complete the final test. The teacher organized the presentations per building and created one folder for each group in the public repository. The test was uploaded to the platform and the teachers had to control that all students had answered the test.

Finally, the teachers organized the workflow using Moodle. They used the platform to inform students of the steps for the next activities, and e-mail to inform when the description of a new activity was available. However, other activities in the course were also carried out in parallel during this period (and published in Moodle) and students had problems to have a unified view of the scenario.

Summarizing, the evaluation of the case study showed the following limitations of the activity flow:

1) Students' data analysis: Manually analyzing the log files was hard to carry out without errors. Also combining the preferences and the log file results for assigning the students expertise was complex and very time demanding.
2) Expert group management: Creating and managing the expert groups was very time demanding because of the groups instability due to drop outs that characterize the first weeks of the course and mixing students from the two lecturing sessions.
3) Activity workflow: Moodle does not facilitate the integration of the activities to create an orchestrated view of the learning flow for both, the teachers and the students.
4) Scalability: Without technological support, these activities are very costly to carry out for a large number of students. The data analysis becomes very complex.

3 System for the Scripted Orchestration

A technological solution has been developed for dealing with the limitations highlighted in Section 2.3. The proposal is to use a computational script as the orchestration mechanism for automating the most demanding tasks. The IMS LD framework supports the authoring and deployment of the activity flow, resulting in a UoL that structures the learning flow of the scenario. Additionally, the proposed UoL (with minor changes) could be used for supporting analogous learning flows. This solution is a proof of concept to show that teaching staff workload can be significantly reduced in any learning situation which combines collaborative activities at different spatial locations supported by portable devices. This section overviews the technological framework that supports UoL as well as the translation process from the original course to its scripted version.

3.1 Course Flow Management Technologies

One of the best-established modeling languages used to computationally represent learning flows is the IMS Learning Design framework [27]. The vocabulary provided by the specification supports the use of a wide range of pedagogical models in the creation of learning courses, including collaborative and blended learning. IMS LD is constructed upon the metaphor of the theatrical play: different actors play different roles. Each role is assigned to a set of learning activities that may occur in sequence or in parallel, depending on whether they are organized in acts or structures. Each activity takes place in a given environment, which consists of a set of learning objects and/or services.

Collaborative learning is supported by means of the use of roles. That is, each course participant can be related to a different role, and the result is that different students may perform different activities at the same time. Furthermore, one course participant could be related to several roles. The combination of the emerging possibilities allows modeling complex collaborative learning models such as *jigsaw*, or *pyramid* [13, 27].

The IMS LD framework also supports the creation of adaptive content material [4]. The offered mechanism is based on the use of the so-called *properties* and *conditions*. That is, the author can define a set of properties, whose value will change during the course activities. The *conditions* evaluate such values to decide whether or not an action needs to be triggered. With such functionality, the course author can create several (maybe interlaced) learning flows and adapt the sequence of activities depending on the specific user's needs.

One limitation of IMS LD is the lack of integration with third party tools. The framework defines the use of a limited catalogue of services, which are *e-mail*, *conference*, *monitor* and *index*. In practice, available services are not able to support complex blended learning flows, where different tools are used in different scenarios.

Generic Service Integration (GSI) proposes a framework to include any kind of web-based tool in the context of IMS LD courses [6,8]. The integration covers authoring, deployment and enactment of courses. First, GSI provides a vocabulary for course authors to describe generic tools that will be used to support certain activities within the course. Then, when the UoL is uploaded to a compliant platform, the tool description is used to select a case-specific tool that matches with the expected functionality. Finally, the tool is instantiated and integrated in the enactment of the course, allowing the interaction of course participants with the third party tool. GSI also offers mechanisms for the information exchange of IMS LD and the external tool, so the course *properties* can be feed by information dynamically retrieved from the third party tool. Other initiatives that attempt to solve the integration problem in IMS LD have been described in the literature (e.g. [2,3,18]). However, a comprehensive review of the state of the art or the discussion bout the appropriateness of these solutions in the presented scenario is beyond the scope of this chapter. A detailed review of these solutions can be found in [6].

In the GSI model, the integration of third party tools is based on case-specific service adapters. In other words, each integrated tool requires a service adapter that translates IMS LD requests into case-specific requests constructed as specified by the tool's API. One of the existing service adapters called *GSpread*, supports the use and management of assessments through the use of Google Forms and Google Spreadsheets [7].

The integration of Google Spreadsheets[1] in a UoL can be summarized as follows: students access a questionnaire (an HTML form) through a hyperlink located in the environment of an activity; on the other hand, teachers own a spreadsheet populated by student's responses, where each row contains data from a single student. Teachers can manipulate the spreadsheet arbitrarily so that they produce a value suitable to be mapped to an IMS LD property. Then, IMS LD retrieves the data contained in the spreadsheet and the appropriate properties are updated.

The GSpread adapter uses the Google API[2] for documents and spreadsheets in order to execute the following actions:

- Before the activity flow starts, the adapter establishes a relationship between the teacher role and her corresponding Google identity. Such action requires manual intervention of the involved participants (the teacher) and uses the support of the SubAuth protocol [5].
- At the beginning of the activity flow, the adapter creates the external service instance (the spreadsheet) and relates it to the questionnaire contained in the UoL so that the answers of such questionnaire are stored in the spreadsheet, which is owned by the teacher.
- During the enactment of the activities, GSpread retrieves the information contained in the spreadsheet and parses it so that the relevant information is used to feed the IMS LD *properties*.

The inclusion of spreadsheets in IMS LD courses serves a double purpose. First, it provides support for assessment, the absence of which is one of the weaknesses of the specification. Assessment is made possible by including HTML questionnaires and using the responses to adapt the course flow. Second, it offers a well-known method to manipulate data, substituting the complex calculate element in IMS LD, which hinders the creation of mathematical formulas based on questionnaire responses.

For the purpose of the work presented in this paper, IMS LD has been used to define and deploy the activity sequence of the course. GSI has been used to integrate specialized data management tools as part of the learning flow. In particular, we have used Google Spreadsheets to administer students' data and to automate the group formation process. The resulting framework, that combines IMS LD and Google Spreadsheets with the integration provided by GSI, is referred as the *orchestration system*.

[1] http://spreadsheets.google.com
[2] http://code.google.com/intl/en-US/apis/spreadsheets/

3.2 The Scripted Course Flow

The orchestration system proposed in this document requires the course flow to be expressed with the IMS LD vocabulary. Such translation process imposes some minor changes to the course flow, which are required to adjust the sequence of activities to the particular needs of the technological framework. We present in what follows a description of the learning flow that resulted after the translation process, highlighting the particular elements that differ from the original flow explained in Section 2.1.

One restriction imposed by IMS LD is the need of computers to deliver the activity descriptions. In practice, it means that the students must go to the laboratory to perform the activities instead of being in any other place such as the library, or home. This fact limits the number of students that can participate in the activity. On the positive side, the orchestration method allows the course flow to be quickly instantiated and enacted, so several course instances can be held in the same day. The script was designed to support five working groups, whose number of members was set to five. As a result, 25 is the number of learners considered in the design of the learning script, whose enactment is expected to last 2 hours. A higher number of students can be supported by simply creating new course instances of the same course. The number of teachers is not restricted. We will refer to all teaching staff members as simply the teacher.

The course follows a blended learning approach: students receive the information through the computer; some of the activities are done on-line and the remaining ones are offline. An overview of the course flow is show in Fig. 1.

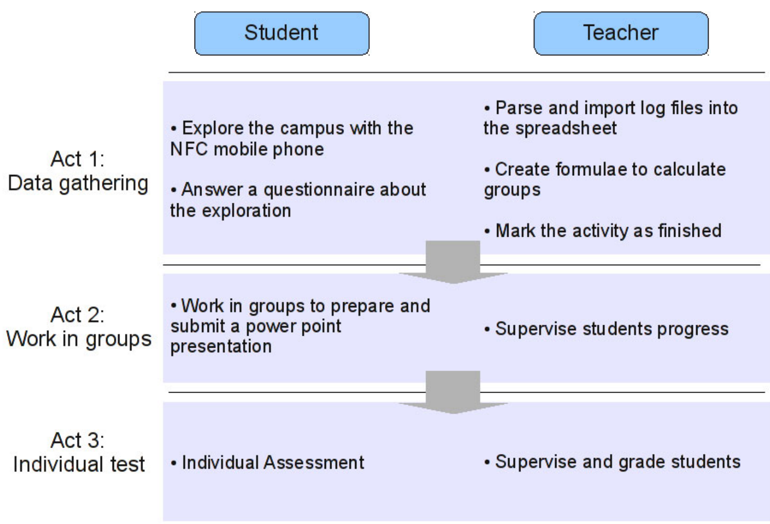


Fig. 1 IMS LD Mapping of the original flow.

3.2.1 First Phase: Discovering the Campus

During the first act, learners visit the campus and acquire the knowledge they will use in later activities. They perform the visit with a NFC mobile phone as described in Section 2.1. When a student returns back to the classroom, s/he has to obtain from the mobile phone the log file generated by his/her activity. Then, s/he uses the course interface to upload such log file into the server. Once finished, they fill in a questionnaire to show their acquired knowledge of the campus. After that, they have to wait until the teacher enables the next phase.

Meanwhile, the teacher has to supervise the learners' activities and track their completion. When all the students have completed both the exploration and the questionnaire, the teacher starts the group formation process. Such activity is divided in two main parts: (i) storing the data in the spreadsheet and (ii) creating groups.

The teacher will use two data sources to create the groups: the answers of the questionnaire and the information of the log files. The former is automatically stored in the spreadsheet, while the latter requires some preprocessing. The processing of the log files results in a comma separated value (.csv) file that contains the relevant information and can be easily imported by the spreadsheet.

Once the information has been loaded in the spreadsheet, each row contains numeric values that summarize the activity and the answers to the questionnaire of a single student. This summary contains, for each student: (1) the number of tags accessed per building and (2) the building expertise, which is the building with the maximum number of tags accessed. The teacher creates the formulas in the spreadsheet so that the output of the activity is finally produced. The calculated output is a number (from 1 to 5) assigned to each student representing the building's expert group.

The criteria to create students' teams considered data from questionnaires and log files. However, the absence of one of these sources was also supported. This fact provides a degree of flexibility to the course flow. For instance, students who could not perform the mobile exploration will also find their corresponding group in the next phase. This requirement is also supported by enabling the teacher to overwrite the groups assigned by the spreadsheet formulas.

When the building's expert groups have been created, the first phase is completed.

3.2.2 Second Phase: Explain the Campus

Few minutes after the campus exploration, the teams are published and the students start the collaborative creation of a document that explains what they consider the most relevant information of the building they have been assigned to. In the original experiment, the students had several days to create and submit the document. However, in this new solution, the document creation was expected to be finished in 30 minutes. The availability of several days was due to the difficulty for the teams to adjust their schedules and meet together outside the classroom. In the scripted version of the course, such scheduling problem does not appear, so the students have to finish the activity in the abovementioned 30 minutes.

The teams then upload the created documents to the course manager while the teacher tracks the process. When all the teams have finished their assignment (i.e. they have uploaded their documents), the teacher enables the third phase.

3.2.3 Third Phase: Reflect about the Campus

In this phase, the delivery of the previously submitted presentations requires no intervention from the teaching staff: the documents are directly accessible from the activity statement. Thus, students may review all the presentations and access to the final assessment task.

3.3 Technical Details of the Scripted Flow

Two types of participants take part in the course: learners and teachers. These are the roles defined in the UoL. Although the learners are divided into groups, there still is a single role for all of them. This is because roles are populated at the beginning of the course, and therefore at design time there is not enough information about the number of required groups. This division is performed in a later step using *properties*.

Both the answers to the questionnaire and the mobile activity logs are stored in a Google Spreadsheet. The use of Google Forms as the questionnaire provider guarantees that the answers will be stored in the spreadsheet without the need of human intervention, being each student's answer stored in a single row of the spreadsheet. The inclusion of the logs information follows a different path, shown in Fig. 2. When a student finishes the activity, s/he is requested to use the resulting log file as the value of a *file property*. All students' log files (that is, all *properties*) are stored in the same folder and are easy to manipulate. Furthermore, because files are related to their owners, it is also possible to easily identify which log belongs to which student. Moreover, the regular structure of the log files allows automatic parsing. A script specially developed for the case performs the log analysis and produces a file with comma separated values containing a summary of the events generated by each student. This summary can then be manually uploaded into the Google Spreadsheet.

The spreadsheet then contains all the data from the log files and questionnaires, where each row represents a single student. At this point, the teacher manipulates the data so that the output of the activity is finally produced. All values are calculated by the spreadsheet, which has been previously modified with the proper criteria. The formulas in the spreadsheet require numeric values, and as a consequence the original questionnaire was modified to include closed response questions to process the answers automatically. The questionnaire includes three types of questions: (1) a multiple choice option in which the students select the building they have visited, (2) a true-false question related to each building and (3) a Likert-scale question to evaluate each building. The use of closed response questions solves two problems: first, offers the possibility of automatically computing the students' preferences. Second, provides the teacher with an easy mechanism to evaluate the students' knowledge about the campus.

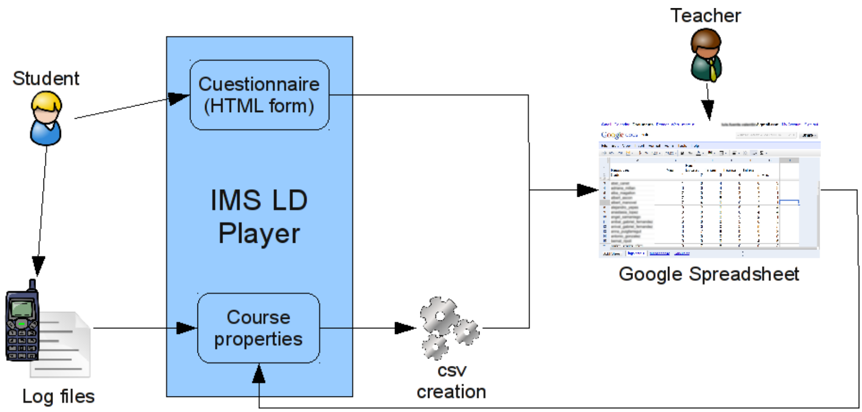


Fig. 2 Data flow for group assignment automation

Once the grouping phase has finished and no group changes are expected in the groups, the teacher marks the *activity* as finished. This action triggers data synchronization between IMS LD and the spreadsheet. That is, the IMS LD player, through the GSpread adapter, requests the spreadsheet's rows using the API offered by Google. The response is the XML-formatted data, from where the adapter parses and selects the relevant information, i.e. the group membership recommendation done by the spreadsheet. Such information, represented as a number and a character string, is the used to feed the *properties* of the UoL.

When IMS LD *properties* obtain their value, the corresponding *conditions* are evaluated and the course flow is properly adapted. There are two types of *properties* whose value is assigned:

- Each student has a *property* called group. The value is a number (from 1 to 5) that says in which team the student has been placed.
- Each group has a *property* called members, which contains the names of the team members.

The second phase of the course flow has been modeled as an IMS LD act: all course participants start at the same time. The act adapts its contents depending on which team the student has been related to.

There are three issues to be solved by the course flow:

1) Which task corresponds to each student?
2) How do students know who their partners are?
3) How do students submit their presentation?

To solve the first question, the course flow has been modeled with five different *activities*, one per building's expert team. The visibility of these activities is controlled by *property values*, so that only one of the *activities* will be shown to each student (see Figure 3). In practice, students receive the activity description that corresponds to their group, and they see no information about the other groups. Each activity description shows the *members* property of the group. Therefore, students are aware of who are their teammates.

```
<imsld:if>
  <imsld:is>
    <imsld:property-ref ref="prop-locpers-group-number" />
    <imsld:property-value>3</imsld:property-value>
  </imsld:is>
</imsld:if>
<imsld:then>
  <imsld:show>
    <imsld:learning-activity-ref ref="la-get-expert-tanger" />
  </imsld:show>
  <imsld:hide>
    <imsld:learning-activity-ref ref="la-get-expert-la-nau" />
    <imsld:learning-activity-ref ref="la-get-expert-rb" />
    <imsld:learning-activity-ref ref="la-get-expert-fabrica" />
    <imsld:learning-activity-ref ref="la-get-expert-tallers" />
  </imsld:hide>
</imsld:then>
<imsld:if>
```

Fig. 3 Conditions used in the IMS LD manifest to show and hide content

The submission of the collaborative document has been modeled as a *local property* whose value is set when students upload a file through a form included in the activity description.

Figure 4 shows part of the resource with a link to such *properties* published in the third phase of the course (that is, in the third act). In this phase, the delivery of the previously submitted presentations requires no intervention from the teaching staff and the documents of all the teams are available to be downloaded. Since file *properties* are directly accessible from the statement, students may review all the presentations and access to the final assessment task.

```
<h2>Grup Tanger</h2>
<div class="tanger-not-submitted">
    <p>No disponible encara</p>
</div>
<div class="tanger-submitted">
    <ld:view-property ref="prop-loc-tanger-file" property-of="self" view="value" />
</div>
```

Fig. 4 Use of the view-property element

The final assessment is an IMS Question & Test Interoperability (QTI) test[3]. Students access this test through a link in the UoL and login to the QTI server. The QTI test is composed of 5 questions: 3 common QTI questions (Multiple Choice, Yes/No and Multiple response) and 2 Google Maps-based QTI questions [20]. For these questions, students locate their answer in a Google Maps map. An example of QTI-GoogleMaps question is in Figure 5.

[3] IMS (2006). IMS QTI Question & Test Interoperability Specification v2.0/v2.1. Retrieved March 23, 2010, from HTTP://www.imsglobal.org/question/index.html

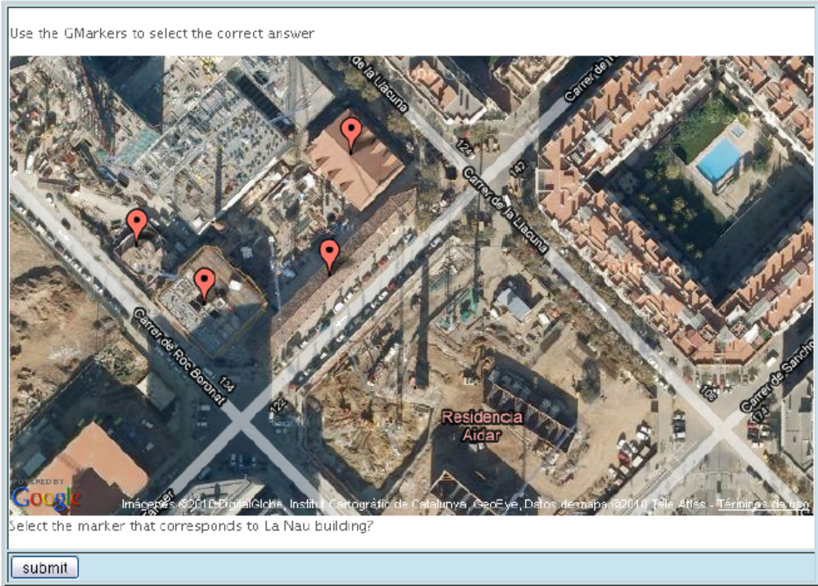


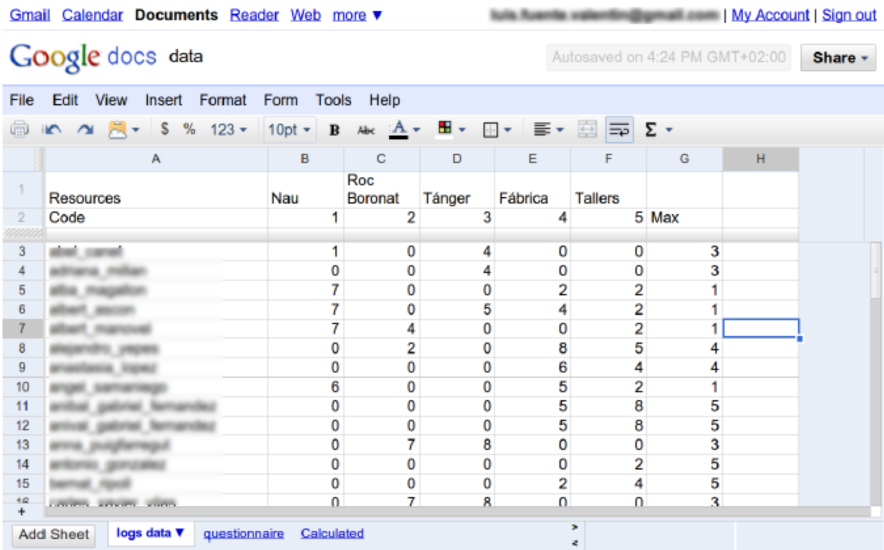
Fig. 5 Example of QTI-Google Maps question where students have to select which marker corresponds with La Nau building

4 Results Analysis of the Solution: A Simulation

This section analyzes whether the orchestration system proposed for the script enactment solves the limitations detected in the activity “Discovering the Campus”: (i) the groups formation process, (ii) the expert groups management, (iii) the activity workflow, and (iv) scalability. With this aim, we propose an analysis that consists in a simulation of the script enactment with some of the data extracted from the empirical study to understand whether the solution proposed deals with the limitations detected.

Part of the students’ data extracted from the empirical study presented in Section 2 has been used in the simulation. Specifically, the simulation has been performed with the 74 log files generated from the exploratory activity in the empirical study. The outcomes of the students’ questionnaire performed after the campus exploration have not been considered since, in the proposed solution, the questionnaire has been modified and transformed to numeric questions.

The first step is the simulation of the expert groups formation process according to the information registered into the 74 log files. For this, three manual interventions are required: (1) to copy the log files to the folder where they will be parsed and processed, (2) to import the resulting *comma separated value* file to the spreadsheet and (3) to insert a set of spreadsheet formulas that capture the group formation criteria. Figure 6 shows the results of the analysis of the 74 log files.



	A	B	C	D	E	F	G	H
1	Resources	Nau	Roc Boronat	Tánger	Fábrica	Tallers		
2	Code	1	2	3	4	5	Max	
3	[illegible]	1	0	4	0	0	3	
4	[illegible]	0	0	4	0	0	3	
5	[illegible]	7	0	0	2	2	1	
6	[illegible]	7	0	5	4	2	1	
7	[illegible]	7	4	0	0	2	1	
8	[illegible]	0	2	0	8	5	4	
9	[illegible]	0	0	0	6	4	4	
10	[illegible]	6	0	0	5	2	1	
11	[illegible]	0	0	0	5	8	5	
12	[illegible]	0	0	0	5	8	5	
13	[illegible]	0	7	8	0	0	3	
14	[illegible]	0	0	0	0	2	5	
15	[illegible]	0	0	0	2	4	5	
16	[illegible]	0	7	8	0	0	3	

Fig. 6 Student activity data imported from the analysis of the 74 log files.

The second step is to simulate the workflow distribution among the potential students participating in the experiment. The activity tree and activity content, is adapted for each student who receives, at the end of the course, a complete view of the learning flow. The end of each phase has to be indicated by manually marking the phase as finished. This mechanism provides a control of the workflow on runtime.

The simulation shows the effectiveness of the orchestration system proposed to deal with the main limitations detected. First, both the module for automating log files analysis and the numeric questionnaires solve the main limitations of the students' data analysis for the first phase. On one hand, this solution strongly decreases the time spent for analyzing all the log files. On the other hand, this automatic approach might support the assignment of students' expertise by diminishing the number of errors when doing this process manually. Moreover, this approach also offers the possibility of modifying the automatic building assignment and to easily adapt the groups to the actual context of the activity.

Second, the scripted course has been designed to support 25 students and can be instantiated several times. Preliminary results on the course deployment showed a quite reasonable cost of the replication process. That is, the orchestration system makes the course as reusable as regular IMS LD courses are. Besides, the NFC tags can be reused from one course instance to another as well as for other similar experiences. It can be said that the solution is scalable to the extent that it is reusable, being each new course instance able to support 25 more participants.

Therefore, the results from the simulation shows that the proposed orchestration system offers a flexible semi-automatic system for analyzing log files and managing the students' building assignments that facilitates grouping tasks alleviating the time investment. Besides, the possibility of producing different instances of the activity increases the scalability of the learning flow.

5 Conclusions

This chapter has presented a proof of concept of a technological solution that supports the automatic enactment of learning activities requiring the orchestration of a complex collaborative learning flow, supported by different computing devices, involving different spatial locations and with a large number of students. The motivating example has been drawn from an experiment that presented promising results in terms of students' motivation and achieved learning but imposing a severe workload on the teaching staff.

To deal with this workload, is has been proposed an orchestration system based on a UoL codified with IMS LD combined with GSI. The use of GSI to integrate services in the context of the UoL allowed the learning flow to coordinate the use of different technologies such as NFC, Google Spreadsheets and QTI. In the designed course, a semi-automatic process of data acquisition and group formation complements the group-dependent scripted delivery of the learning material. The enactment simulation of the proposed script showed that this solution would provide significant reduction of teaching staff workload. The major limitations of the previous experiment disappear with the semi-automatic orchestration of the learning flow. One added value of the proposal is the simplicity of the replication process, which allows reusing the course flow with a reasonable cost. As a conclusion, the presented solution sheds some light on how technology can facilitate the orchestration process of complex and innovative collaborative learning using portable technology such as smart phones.

As next steps, we are working mainly into two main lines. On the one hand, the solution presented in this work has been already enacted as part the introductory activity of the engineering courses of the University Pompeu Fabra. The activity was successfully enacted and the data analysis is still under development. The evaluation results of this new experiment will complement the results of the simulation presented in this work to analyze whether the orchestration system proposed deals with the limitations detected when applied to an actual educational context.

On the other hand, we plan to study how the orchestration system proposed could be applied to other similar courses in order to understand the suitability of the solution to be applied into other learning contexts, thus extending the scalability of the course flow beyond the presented scenario.

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