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Cloud Services, Interoperability and Analytics within a ROLE-enabled Personal Learning Environment

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Abstract: The ROLE project (Responsive Open Learning Environments, EU 7th Framework Programme, grant agreement no.: 231396, 2009–2013) was focused on the next generation of Personal Learning Environments (PLEs). A ROLE PLE is a bundle of interoperating widgets – often realised as cloud services – used for teaching and learning. In this paper, we first describe the creation of new ROLE widgets and widget bundles at Galileo University, Guatemala, within a cloud-based infrastructure. We introduce an initial architecture for cloud interoperability services including the means for collecting interaction data as needed for learning analytics. Furthermore, we describe the newly implemented widgets, namely a social networking tool, a mind-mapping tool and an online document editor, as well as the modification of existing widgets. The newly created and modified widgets have been combined in two different bundles that have been evaluated in two web-based courses at Galileo University, with participants from three different Latin-American countries. We measured emotional aspects, motivation, usability and attitudes towards the environment. The results demonstrated the readiness of cloud-based education solutions, and how ROLE can bring together such an environment from a PLE perspective.

Keywords: Responsive Open Learning Environments, Personal Learning Environment, Widget Bundles, Cloud-based Tools, Cloud Learning Activities, Cloud Education Environments.
Categories: L.2.3, L.2.2, L.3.0, L.3.5, L.3.6

1 Introduction

Cloud computing is a major trend nowadays, with recent studies positioning it as one of the short-term adoption technologies for education [STEM+ Education, 12]. Cloud computing is essentially about expandable and on-demand services, tools and contents that are served to users via the Internet from specialized data centers. Cloud computing resources support virtualization, grow on-demand and collaboration. Cloud-based tools

for collaboration have the potential to engage students, by allowing them to interact and brainstorm solutions, elaborate reports, and create conceptual designs. This approach has the potential to enable and facilitate both formal and informal learning for the learner. It also promotes the openness, sharing and reusability of learning resources on the web [Mikroyannidis, 12]. Cloud-based tools can interoperate with other systems, offering the possibility to orchestrate services that previously were seen as standalone Web 2.0 tools and thus to create an ecosystem for a comprehensive and integrated learning experience. In this paper, we focus on cloud-based tools that can interoperate for creating learning experiences.

We investigate the potential of using a cloud-based infrastructure in order to enable a Personal Learning Environment (PLE). PLEs allow individual learners to access, aggregate, configure and manipulate assets of their own current educational experiences. PLEs have a learner-centric orientation where learners are provided with the facilities to incorporate the use of new services and tools in a simple manner while at the same time having the control over the environment. They are opposed to monolithic approaches of integrating all services into a single architecture [Chatti, 07].

The ROLE project aimed to enable learners to assemble and use their own learning environments, which become advanced Personal Learning Environments (PLEs) [Friedrich, 11]. ROLE technology is centered around the concept of self-regulated learning, aiming at creating autonomous learners that are able to plan their learning process, search for suitable resources independently, learn and then reflect on their learning process and progress. Using ROLE's techno-pedagogical infrastructure, we have built a psycho-pedagogical setting adapted to the specific needs of our course and our students.

This paper is organized as follows: after this introduction, the second section describes the cloud services used for this experience, the cloud interoperability service architecture used for deploying an orchestrated experience to the students, and the cloud computing infrastructure used. In the third section, we describe the test-bed and the two courses used for this experience, the learning activities that were required from the students, the performance of the students after completing each activity and the evaluation results that include usability, motivational and emotional factors, and the analytics of the user interaction behavior within the ROLE PLE and cloud-based tools. Finally lessons learned, conclusions and an outlook are given.

2 Cloud Services within a Role Infrastructure

In this section, we briefly discuss the key points of the technical realization of the widget bundles that were specifically designed for the Galileo University test-bed. These widget bundles involved the development of three new widgets that used cloud-based services: the mind-mapping tool MindMeister [MindMeister, 12], a Google Docs widget and the Facebook discussion widget, all of which are compliant with the OpenSocial specification [OpenSocial, 12].

We also proposed a number of improvements to the specifications of two existing widgets, namely ObjectSpot [ObjectSport, 12] and MediaList. The improved specifications regarded the addition of Inter-Widget Communication and Monitoring and the testing of a fresh ROLE SDK installation.

2.1 Cloud Interoperability Service (CIS)

To address the interoperability of different cloud-based services with the ROLE system it was necessary to create an integration service that acts as a backend service to access the RESTful based APIs of the cloud-based services used for the widgets. This Cloud Interoperability Service (CIS) to host an interoperability architecture with many services as will be described, and to address the *same origin policy* restriction [W3C Same Origin, 12].

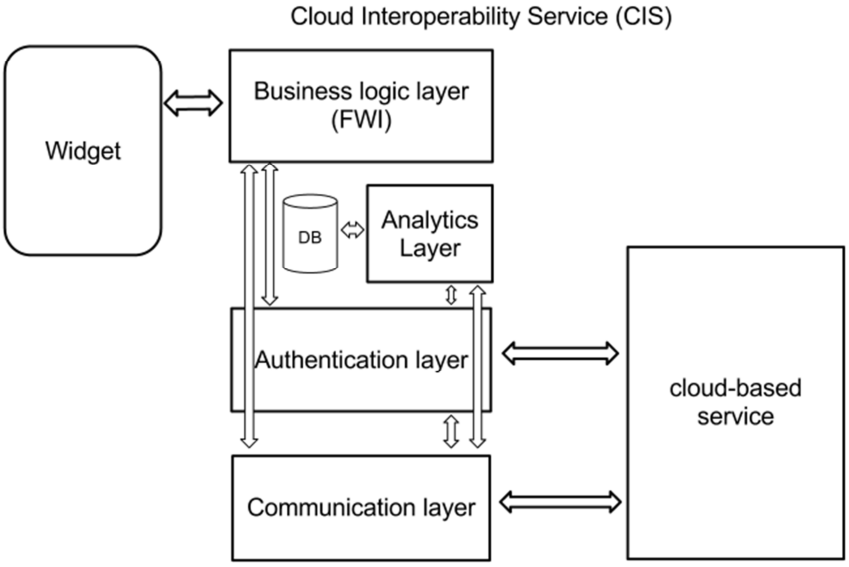

Figure 1: The Cloud Interoperability Service.

As described in Figure 1, the architecture built for the CIS consists of the following layers: the first layer is a business logic layer that contains a Functional Widget Interface (FWI) [Soylu, 12] JavaScript-based library. It contains all the business logic necessary to implement the desired behavior of the widget. This layer is used directly by the widget within the ROLE system. Later in this section, we will explain this layer in detail for each widget.

Second, an analytics layer is used to record user behavior and interaction data from the cloud-services, and send it to an analytics database for further processing. The recorded data provide useful information for usage analysis, collaboration level and behavioral patterns in cloud services. All actions that the cloud-service makes available are retrieved via this layer, i.e. for the Mindmeister cloud-service we collect information on how many nodes were created, who created and edited them, at which date and time, among other relevant information. Thus, this layer gives us the ability to collect information on the cloud-services. The combination of this information with further information collected from the ROLE Contextualized Attention Metadata [Schmitz, 11] renders a more accurate image of user behavior.

Third, the CIS has an authentication layer that handles the required tokens exchange for application and user authentication: the tokens are used for future RESTFul API calls. Authentication takes place between the CIS and the cloud-based service: first the CIS is authenticated to the cloud-service itself with a registered application key (api-key) provided by the cloud-service which is used to identify the CIS for accessing the cloud-base service API, and second the users are authenticated using the login url provided by the cloud-based service with the corresponding parameters for credentials and requested access permission. After obtaining the authentication token this layer makes it available to other layers as needed or for third party services where the CIS is being used. (These services are accessed via widgets within the ROLE system). Although ROLE provides mechanisms for OAuth [ROLE Project, 2012] either as a consumer or provider behavior, the tokens-based authentication is not supported, therefore it is included in the CIS. Figure 2 shows the CIS first-time authentication mechanism: it begins with having the learner login into the cloud-based application, and grants access to the CIS and thus the ROLE system. This token is stored in the Google Fusion Tables [Fusion Tables, 12] for further sharing it with the ROLE system.

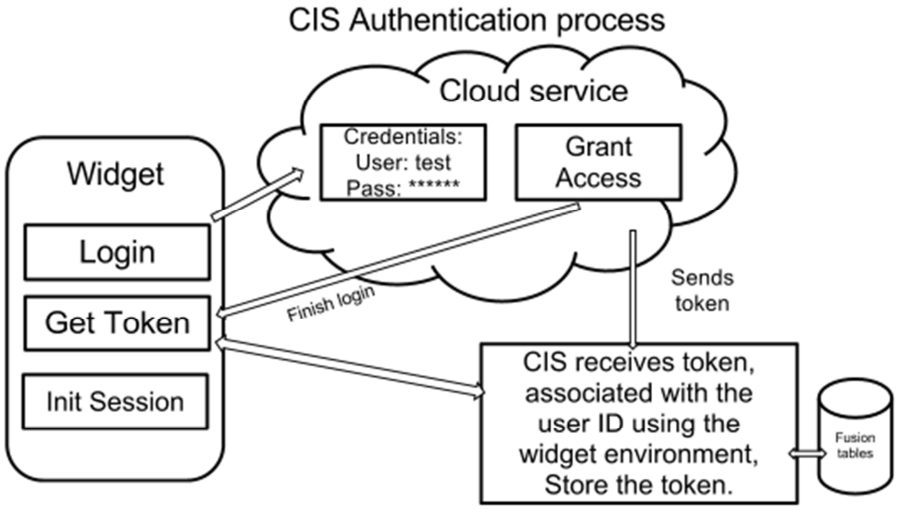

Figure 2: CIS First-time Authentication Process.

Fourth, RESTful based calls to interoperate with the cloud-based service are done via a communication layer. The business logic layer controls the communication and the authentication layer.

2.2 Two widget bundles

In order to address the requirements of the courses and provide a comprehensive learning experience to our students, we offered them two different widget bundles: the first widget bundle consisted of the following six widgets: ObjectSpot, Binocs

Media Search, MediaList, EtherdPad, Mind Map and Facebook. The second widget bundle included three widgets, namely Google Docs, Mind Map and Facebook.

The ObjectSpot search widget allows learners to find online resources from a variety of bibliographic sources, including CiteSeer and Google Scholar. Binocs focuses on media search, allowing users to search for learning content in various Web 2.0 platforms like YouTube, SlideShare, and Wikipedia. Additionally, both widgets provide access to repositories of Open Educational Resources (OER), containing free learning material of high quality. Some of these repositories are OpenLearn (http://openlearn.open.ac.uk/), OpenScout (http://learn.openscout.net/), and Globe (http://www.globe-info.org/).

The Media List Widget allows the user to create custom media lists based on the search results from the Binocs widget.

The EtherPad widget is a text editor that allows users to write a document collaboratively with their peers in real-time. When multiple authors edit the same document simultaneously, any changes are instantly reflected on everyone's screen. This is particularly useful for meeting notes, drafting sessions, education, team programming, and more.

The Mind Map widget is a tool that delivers the functionality to create collaborative mind maps and reuse previously created maps as learning resources. The Mind Map widget uses the OpenSocial specification, as well as the MindMeister embed API [MindMeister embed, 12].

The mind-mapping editor enables the user to create and edit maps, ideas, nodes, and other actions. To achieve the desired operation and to receive elements from other widgets and incorporate them automatically into the map the Open Application specification is utilized [OpenApp, 12]. It was designed and implemented using business logic and authentication/communication libraries in order to interoperate with the MindMeister RESTful services using the CSI. This allows systems communication for interacting with the mind map (instead of a simple map embed) for the publication and listening of widget events (i.e. add an item to a map, a map published for discussion, etc.).

The Facebook discussion widget was implemented according to the OpenSocial Gadget specification [Facebook Comments,12]. The widget offers a comments area for collaboration and communication about a mind-map or document.

To push forward the envisioned ROLE real-time communication and collaboration infrastructure, it was necessary to provide communication between widgets, especially for sending events originating in various widgets (ObjectSpot, Binocs Media Search, MediaList, EtherdPad) to the mind-mapping widget. Likewise, in the case of the ObjectSpot widget, it was necessary to enable communication through events according to the Open Application specification. In the case of the MediaList widget, however, we wanted to be able to add a new broadcast event to send items stored in a list to the mind-map and reflect them as new nodes in the map. Figure 3 shows the first widget bundle architecture and Figure 4 a screenshot of that first widget bundle in action.

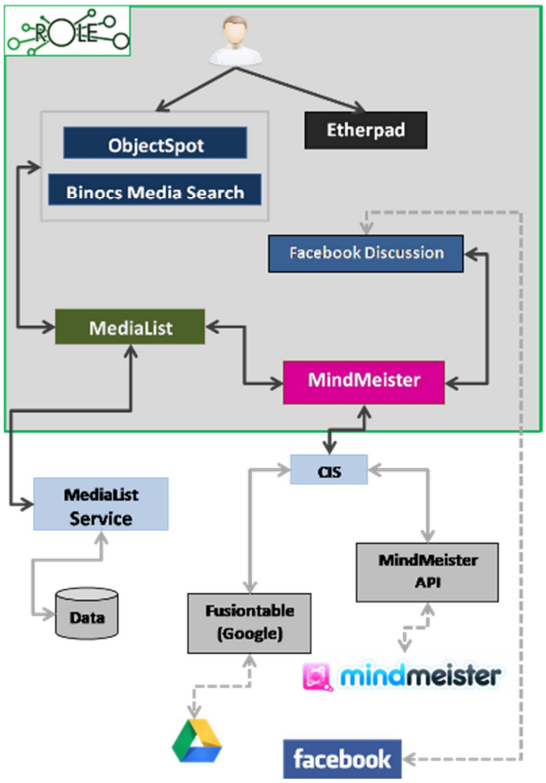

Figure 3: The first widget bundle architecture.

In the second widget bundle, we added a Google Drive widget (see Figure 5) that enables the users to interact with their files. Google Drive allows the user to store files, share exactly with whom they want and create documents using the Google Docs suite. The 'widgetisation' of this service renders these actions available within the widget environment, that is, the PLE. The widget was developed based on the OpenSocial specification, using the Google Drive SDK and the Google Drive API technologies, as well as the JavaScript client library provided by Google. This library provides functionality for authenticating through OAuth, obtaining user information and interacting with files and documents. Because Google provides this library, it was not necessary to use the CIS in this case, since all the CIS provided functionalities are included within the library.

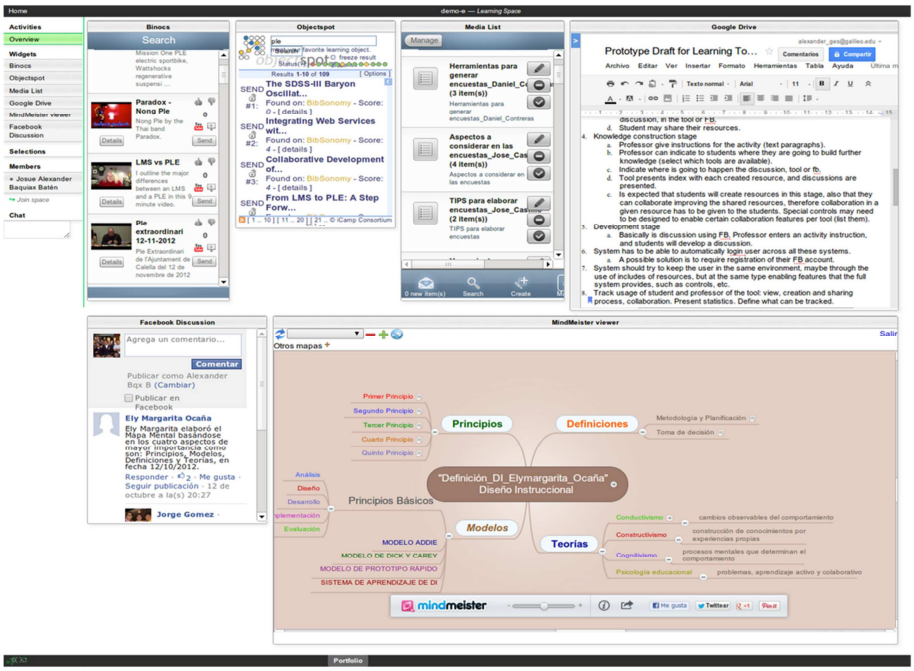

Figure 4: The widget bundle in action.

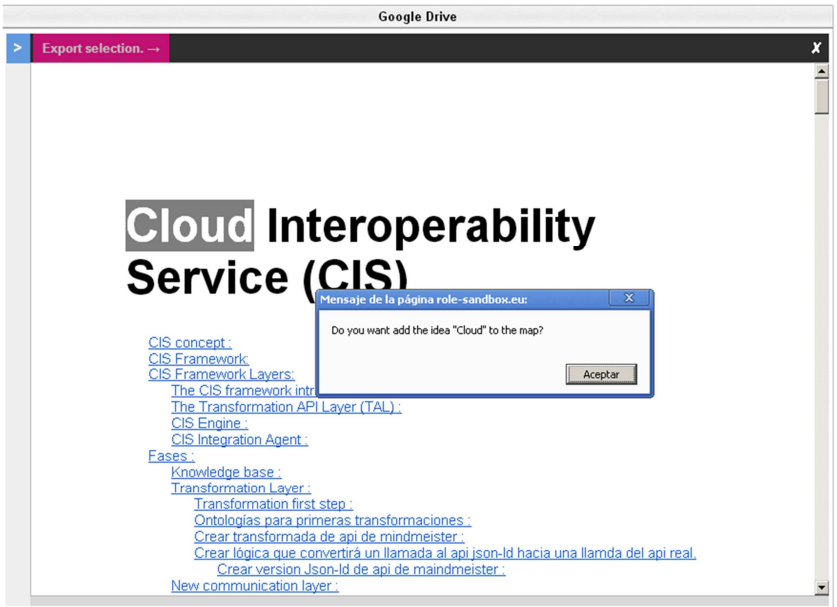

Figure 5: The Google Drive widget in a selection mode to send text to the mind map.

Inter-widget communication (IWC) functionalities enable the user to select a text from the document and send it as an IWC event (also as an OpenApp event) to create a new mind map node. Getting the selected text within a document was performed by getting the static HTML version of a document through the Google Drive client library and inserting it into the widget as a "preview" version. Since this view was already available in the widget, the text could be accessed through the CIS.

2.3 CAM User Interaction Registry

The ROLE technology provides a Contextualized Attention Metadata (CAM) web service that offers a simple way to store and retrieve monitoring data of inter-widget communication using the CAM schema and architecture to capture behavioural information within different applications [Butoianu, 10] [Schmitz, 11]. The ROLE project offers a widget that monitors the behaviour of the user when IWC events are triggered [Friedrich, 11]. For our research objectives it was required to monitor the behaviour of users and their interaction with specific cloud-based applications. For this reason we created a CAM User Interaction Registry as a Javascript library that can be included within any widget. This library adds callback functions to any chosen element on the Document Object Model (DOM) and executed when a DOM event is triggered on the element by the user, such as clicks, text inputs, mouse-select texts, etc. This data is then sent over to the CAM web service for storage and further analysis. The registry was added to all widgets. The registry was limited to monitor the actions recorded as clicks on anything within the widget. However, if the widget includes an embedded object as an iframe (for instance the Google Docs Editor, or the Mindmeister map editor) it is only possible to monitor *that* the user has been within the widget, but not his more specific actions. These, however, can be retrieved via the CIS Analytics.

2.4 Cloud Infrastructure

It is worth mentioning that the education environments were fully enabled on the cloud, both at the infrastructure and the application level. The cloud infrastructure of Amazon's Elastic Compute Cloud (EC2) [Barr, 06] and the Google Fusion Tables [6] were used, the first one for hosting the whole ROLE system and the second one to store and manage token identity across multiple services. Cloud technologies can be dynamically adapted allowing optimum resource utilization and provides availability, flexibility and scalability [Leavitt, 09], important factor for further deployment of the system on a university wide scale. Thus, the implemented environments can serve as true test-beds for cloud-education environments.

3 The Test-Bed

The test-bed was set up in the Institute Von Neumann (IVN) of the Galileo University, Guatemala. IVN is an online Higher Education Institute (HEI) that delivers educational programmes across Guatemala. These programmes are also available for other Spanish speaking countries around their hinterland.

3.1 Test-bed description

Students at IVN are mostly adult learners who also are in employment at the same time. The IVN courses are similar to any other University course, although the most significant difference is that IVN students do most of their learning during the evening or at weekends. IVN offers fully online learning programmes, which generally do not contain any synchronous sessions. Students are expected to spend around ten hours per week for studying the supplied materials in the courses. This also includes carrying out any learning activities as well as interacting online with other students. All courses are organized in weekly units, based on a variety of online materials (e.g. multimedia, interactive animations, etc), downloadable material in addition to the learning activities. The course material is delivered to IVN students using a customized version of the .LRN Learning Management System (LMS) [Hernandez & Prado, 07]. Student-to-student communication is also supported through dedicated online forums. Teachers and instructional designers create and upload all teaching and learning material into the LMS.

In this test-bed, a series of experiments were deployed with respect to ROLE Environment and the described specially developed widget bundles, that were designed to support the learning activities for two courses, the first one being "Building online activities", and the second "Introduction to Instructional Design". Both courses are part of the e-Learning certification programme of the university. This programme is particularly targeted to meet the needs of practitioners, i.e. university professors, and instructors who want to create and deploy their experiences using e-learning delivery methods. The students participating in this case study originated from four different countries: for the first course 15 participants came from Guatemala, six from El Salvador, and nine from Honduras, for the second course 35 came from Guatemala and two from Spain. All students had previously used cloud-based learning activities and tools in other courses, thus they were quite familiar with online services and tools.

The professors teaching the courses introduced the students to new concepts, including PLEs, self regulated learning (SRL) and ROLE, with the purpose of raising awareness about their benefits with a premise of potentially engendering mindset change amongst them. The students were guided to engage in an interactive learning process that was presented as having benefits for long term knowledge acquisition. It was also relevant for their forthcoming assessment regarding the assigned learning activities [Friedrich, 11]. This helped to encourage them to use the ROLE system. Observation of the students' usage of the PLE and collected feedback from both the professor and the students, through interviews and questionnaires, took place. It is important to note that the "students" in the group were mostly active HEI professors at their home universities rather than conventional undergraduate students. The first course lasted for four weeks and the second for five weeks but only the first course had assignments that strictly required use of the PLE.

3.2 Scenario

The following scenario was designed to test the ROLE cloud-based learning activities that had been defined. The professor assembled a widget bundle that was the basis for individual PLEs of the students, as shown above in Figure 4 for the first course. The

first row shows the search widget "Binocs Media Search" and also the "ObjectSpot" widget. The third widget is the media list. The second row had the mind-mapping tool and the EtherPad widget, and the third row contained the social network widget for discussion. It had been decided beforehand to use a social networking site for discussion, based on previous experiences [Hernandez, 11]. No further ROLE collaboration features were used in this part of the case study.

During the first learning activity assigned to students, the PLE and related concepts were introduced to the students, with supportive material such as step by step instruction, video-tutorials and user manuals custom made for this experience. In the first course all learning activities required a research part first, therefore, the students were asked to search using the previously mentioned search widgets, then collect relevant resources in the list widget. They were then asked to create a report using the EtherPad widget, select relevant terms and their relations and represent them in the mind-mapping widget. Finally, the students published their mind-maps in the dedicated course LMS space and discussed their use of them using the social networking feature that had been provided.

The second course used a different widget bundle. The Google Docs widget was used for collaboration; some activities had to use mind-map; discussions were held via the Facebook widget or the built-in collaboration features of Google Docs. Both courses' activities have a summative evaluation for the course grading. A participant's grade is calculated from the evaluations of her course activities, participation and collaboration in the course and online discussion.

3.3 The Learning Activities

3.3.1 First Course

Four learning activities were assigned to the students. The first one (activity #1) was searching for web services that enable the creation of learning material or use of tools for learning activities. This task was followed by summarizing the characteristic and potential educational benefits and classifying them using an initial taxonomy given by the professor in a shared mind-map. In addition all the "students" (who were professors themselves) were also given the opportunity to discuss their contributions and how they, as individuals, might apply the pedagogical approach in their own classrooms.

The second learning activity (activity #2) contributed to the overall research about how to measure course quality through online surveys with a target group of students. In this case study, it was decided that each student would search, list, summarize and reflect knowledge by recording it in a mind-map. This included to create the online survey using Google forms, based on a design previously proposed for the actual course survey. In this instance the mind-map to be created would be individual, and could be shared with the rest of the students. At this stage the students were asked to discuss two or three of their published mind-maps using the social network widget.

The third and fourth activities (activity #3 and #4) were similar in process to the second. The objective of the third learning activity was to summarize a proven process for the creation of storytelling educational activities and then to present one set of learning materials based on that process by using one of the following online tools: goanimate.com, pixton.com, xtranormal.com. The fourth learning activity

focused on modelling a process for creating visually attractive digital posters with educational themes using glogster.com. The students had to present their work and discuss aspects of it with each other. The results of the activities were graded. The means of the grades achieved are given in Table 1.

3.3.2 Second Course

Within the second course the following six activities were carried out: in the first week (activity #1) students were required to create a mind map within ROLE that represents the principles, models and theories behind the *Instructional Design* concepts presented during that week. Additionally, they had to choose a peer's mind map, analyze and comment on it over Facebook and thus start a discussion with the original author.

The second week had two activities. In the first activity (activity #2), the students had to create an analysis of one of their own courses (general objectives, intended audience, timeframe, academic requisites, etc.). They had to use a template that was created and published via Google Docs for that purpose (additional templates were made available for the following activities). The work had to be done in groups of three persons. Interaction and communication between the group members and the professor took place through Google Docs comments, via chat tools or through Facebook. The second activity (activity #3) was to give a general definition of the course (specific objectives, topics, activities, resources, indicators). Again, a template was provided in Google Docs.

The third week had three activities. The first activity (activity #4) was about creating a mind map that reflects the structure of the course under development – it had to contain the course units, all topics and objectives, learning activities and additional resources to be used. The second activity (activity #5) was to create an introductory unit for the course that contains the course's methodology, timeframe, objectives, topic list, assessment structure – again based on a shared template. The third activity (activity #6) was to create the first learning unit of the course, including the introduction to the course topic, unit content and learning activities in detail, once more using a template. All activities included collaboration and communication between group members and the professor, through the collaboration tools already mentioned.

Again, the results of the activities were graded. The means of the grades achieved are given in Table 1.

3.4 Authentication

In order to facilitate the adoption and usage of the system, we decided to allow students to use Google accounts to register to the PLE and to the MindMeister mind-mapping tool. The Google accounts were provided by the professor, and were created only with the purpose to be used on this specific course. The Facebook authentication was done with the students' personal accounts.

3.5 Students performance

For each one of the learning activities a summative evaluation was created by the professor, assessing the tasks and objectives of each activity, including the

educational and meaningful use of the cloud-service for representing the desired learning outcomes. The course has a summative value of 100 points, some of the activities and its values are presented in this paper, Table 1, in the context of the Cloud Education Environment within the PLE, the rest of the activities are performed outside of this environment, such as quizzes, or complementary activities or assignments using the traditional Learning Management System. The professor's evaluation of the student's learning activities is shown in Table 1.

	First Course	*Second Course*
Activity #1	*7.09/10*	*4.29/5*
Activity #2	*7.38/10*	*9.18/10*
Activity #3	*8.38/10*	*8.43/10*
Activity #4	*8.70/10*	*2.75/3*
Activity #5	*N/A*	*6.43/7*
Activity #6	*N/A*	*13.37/15*

Table 1. Summary of scores obtained by students, notation is current student's average out of the total possible value for the activity, course is evaluated from a total of 100 points.

We can see that in the first course, activities grades were AM 89 and the final grade for this course was AM 89, which interestingly is the same value that we observe to the previous year's edition of this course, where no ROLE-based PLE was used. That is, the application of the learning environment did not change the course outcomes as far as these are reflected in the course grades. For the second course the results are similar, the activities grades were AM 85 and previous course edition had equal value, and for final grade AM 89 while in previous edition was AM 84, in general for both courses students performed well. Only those students with a low activity (for personal reasons) also had low scores. This indicates that although the ROLE PLE and cloud-services were new for most of the students, they still completed the learning activities successfully.

4 Evaluation

We performed three different evaluation of the course environments, namely Perceived Usefulness and Ease of Use (PUEU) evaluation, emotional aspects evaluations and evaluation of automatically logged usage data.

4.1 Perceived Usefulness and Ease of Use

The participants of the evaluation of the ROLE-enabled PLE were asked to answer a short online survey. The purpose of this survey was to gather user feedback both specifically about the ROLE widgets and technological issues, as well as more

generally about the perceived usefulness and ease of use of PLEs, via questions based on the Technology Acceptance Model (TAM) [Venkatesh & Bala, 08], [Vankatesh & Davis, 00]. With the questionnaire both quantitative data – the participants were asked to state their dis-/agreement to statements on the usefulness and ease of use of the system on a scale from 1 to 5 – and qualitative data – via text questions on the strengths and weaknesses of PLEs and ideas of 'perfect' PLEs – were collected. Since all of the participants were also teachers, the survey contained questions about the perceived usefulness and ease of use of PLEs both from the perspectives of the learner and the teacher. A total of 19 participants for the first course and 36 for the second responded to the survey.

The participants stated their dis-/agreement to the following statements, among other statements, on a scale from 1 to 5, with '1' meaning 'strongly disagree', '2' 'disagree'; '3' 'neutral', '4' 'agree' and '5' 'strongly agree'. That is, a value > 3 signalizes a tendency towards agreement with the respective statement, a value < 3 signalizes disagreement. The participants of the second course gave (only) slightly better evaluations compared to the participants of the first course. In the following, the evaluations from both courses have been pooled together, we name their arithmetic means (AM) and standard deviations (SD):

- *I would find a PLE useful for my work.* AM: 3.53, SD: 1,11
- *I would expect a ROLE-based PLE to be useful for my students.* AM: 3.08, SD: 1.19
- *I would accomplish my work more effectively with a PLE than with the learning technology I am currently using.* AM: 3.31 SD: 1.17
- *I would expect that my students would accomplish their work more effectively with a ROLE-based PLE than with the learning technology they are currently using.* AM: 2.91, SD 1.25
- *I think the system was easy to use.* AM: 3.18, SD: 1.24
- *I expect that it would be easy for my students to use a ROLE-based PLE.* AM: 3.45, SD: 1.11
- *Using a PLE would improve my motivation for learning.* AM: 3.33, SD: 1.18
- *I expect that using a ROLE-based PLE would improve my students' motivation for learning.* AM: 3.22, SD: 1.02
- *Using a PLE would enable me to learn in an independent manner.* AM: 3.45, SD: 1.16
- *I expect that using a ROLE-based PLE would enable my students to learn in an independent manner.* AM: 3.44, SD: 1.07
- *I predict that I would frequently use a PLE if I had access to it./ I think I would use the PLE frequently.* AM: 3.35, SD: 1.27
- *I predict that my students would frequently use a ROLE-based PLE if they had access to it.* AM: 3.31, SD: 1.09

These results proof a positive tendency towards the usefulness and ease of use of ROLE PLEs, as well as their potential to support motivation and independence of learning. The text answers of the questionnaires give additional hints to interpret the data: the participants see the advantage of tailoring a learning environment from tools that are partly already known (GoogleDocs, social networks, others) to both learners and teachers. Still, using a PLE requires learning effort, that is, both professors and students must get used to the environment. This might be a lower burden for the students than for the professors: "Students are ready to begin using a PLE for their daily studies to a wide extend, because the new generation learns very quickly and is

able to use that knowledge." However, although the idea of such an environment is to empower learners to learn independently – and the participants agree that such an environments supports independent learning as the data above show – one still has to be careful not to restrict the learners' possibilities: "I teach computer science classes and they [my students] are capable of doing great things and they understand the technology. But if I would put them to use ROLE they would say I am limiting them."

The participants see the potential of integrating learning analytics into a ROLE PLE and thereby support both self-regulated learning and supervision by a teacher: "[For my students I would like to] have a system to visualize the progress within a week, in what areas a student has worked more or less." "In a collaborative environment I could measure the interactivity of the students."

Finally, the participants remind us that internet access and connectivity are limited in some regions – quite a lot regions in the world, actually – which restricts the applicability of cloud-based environments in general and an environment like ROLE in particular.

4.2 Emotional aspects evaluation

For both courses, we measured emotional aspects, in a pre-test and a post-test. The instrument was based on the Computer Emotion Scale (4pt. scale, in a range where 0 is 'none of the time' to 3 is 'all the time') [Kay & Loverock, 08] developed by Kay and Loverock to measure emotions related to learning new computer software/learning tools in general. With the pre-test, the emotions before using the PLEs have been measured, with the post-test the respective emotions after the course activities have been assessed. The pre-test gives an impression on the bias of the participants, before they have used the environment. The results are shown in the following tables 2 and 3, and they are summarized in table 4 and figure 6:

	Pre-test results		Post-test results	
Emotion	AM	SD	AM	SD
Satisfied	2.79	0.42	2.26	0.81
Anxious	1.61	0.96	0.94	0.85
Irritable	0.26	0.45	0.47	0.84
Excited	2.63	0.60	1.95	0.91
Disheartened	0.26	0.45	0.42	0.61
Dispirited	0.53	0.61	0.58	0.51
Insecure	0.53	0.61	0.47	0.61
Frustrated	0.26	0.45	0.32	0.58
Curious	2.47	0.61	2.05	0.85
Nervous	0.42	0.61	0.37	0.60
Angry	0.16	0.37	0.32	0.48

Table 2: For the first course, results from pre and post tests, the arithmetic mean (AM) result per emotion measured and the standard deaviation (SD).

	Pre-test results		Post-test results	
Emotion	AM	SD	AM	SD
Satisfied	2.21	0.51	1.79	0.66
Anxious	1.39	0.77	1.30	0.69
Irritable	0.54	0.51	0.67	0.56
Excited	2.08	0.72	1.92	0.83
Disheartened	0.50	0.59	0.46	0.59
Dispirited	1.04	0.55	0.88	0.54
Insecure	0.92	0.65	0.79	0.59
Frustrated	0.29	0.46	0.46	0.59
Curious	2.33	0.70	2.33	0.64
Nervous	1.04	0.69	0.71	0.62
Angry	0.21	0.41	0.46	0.59

Table 3: For the second course, results from pre and post tests, the arithmetic mean (AM) result per emotion measured and the standard deaviation (SD).

The summary with the four emotions of the CES [Kay & Loverock, 08] scale is presented in Table 4, organized as Happiness (satisfied/excited/curious), Sadness (disheartened/dispirited), Anxiety (anxious/insecure/helpless/nervous) and Anger (irritable/frustrated/angry).

	First Course		Second Course	
Emotion(4pt. scale)	Pre-test results (AM)	Post-test results (AM)	Pre-test results (AM)	Post-test results (AM)
Happiness	2.208	2.014	2.632	2.088
Sadness	0.771	0.667	0.395	0.500
Anxiety	1.117	0.935	0.853	0.596
Anger	0.347	0.528	0.228	0.368

Table 4: For the both courses, main emotions summarized (arithmetic means).

Figures 6 illustrate the emotional aspects of the participants for both courses regarding the usage of cloud-based tools that were required in the learning activities. The results show little difference between the pre-test and post-test. Results with a 4-point scale show a neutral reaction to “happiness” although it slightly decreases after having the experience. Regarding the perception of “anger”, the difference between the pre- and post-test is minimal. We also observed low levels of “sadness” and a small decrease after having the experience. The perception of “anxiety” has also been low, although it was measured somewhat higher than “anger” and “sadness”.

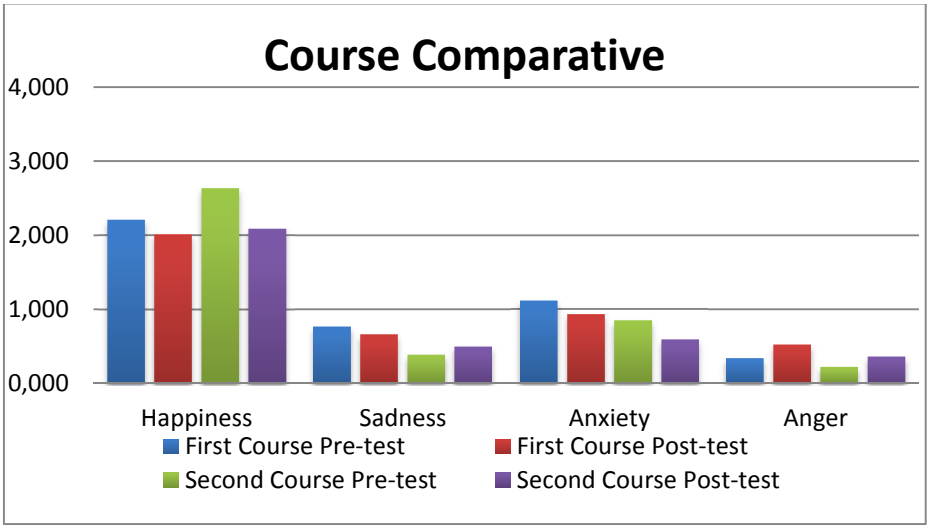

Figure 6: Bars-chart of the results for both courses.

Negative emotions such as Sadness and Anxiety show a slight decrease, which is positive, while Happiness has a small decrease and Anger has a mild increase as well. This corresponds to the impact that using a new learning environment may have into the learning process. No remarkable changes in the measured emotional aspects were recorded between the pre and post-test. It is important to mention that the cloud-based tools used in this study were not new for the students, since they had already used them in previous courses but not within an environment such as the ROLE PLE. We therefore conclude that the recorded usability results reflect the new ROLE PLE experience as a whole, rather than the usage of the individual cloud-based tools.

4.3 CAM User Interaction Registry and CIS Analytics Results Evaluation

The results presented in this section are only for the second course, since the CAM User Interaction Registry was not ready when the first course took place. As described, there were six activities, two of them involving the mind-mapping tool, four using mainly the Google Docs, and all with the possibility to use a discussion tool. The results reported in this section mainly concern the usage of the mind-mapping tool, that is, the course activities #1 and #4.

The first notable behaviour identified is that none of the students used the ROLE PLE to do their learning activities that were assigned using the Google Docs tool. After interviewing both professor and students, it was concluded that the students had substantial previous experience and knowledge of Google Docs, which led them to use the Documents in the environment provided by Google, instead of the ROLE PLE.

The CAM Registry tracked the sessions in the system by having continuous activity in the ROLE PLE in time no longer than one hour. In case the interval was more than one hour it was taken as another session.

	Activity #1	Activity #4
0 - 2 Sessions	40%	69%
3 - 6 Sessions	40%	17%
> 7 sessions	20%	14%
Widget Actions	up to 213 actions: 74%	up to 18 actions: 69%
Avg. Time in Mind-Map	27 mins.	22 mins.
Avg. Time in Facebook	3.5 mins.	N/A
Students' total time in ROLE-PLE	66% between 0-22 mins.	71% between 0-16 mins
Mean of focus change between widgets	34	17

Table 5: Summary of data gathered by the CAM User Interaction Registry.

For the activity #1, 40% of the students had between 0 and 2 sessions, while other 40% of students had between 3 and 6 sessions, while for activity #4, there was a decrease of the need for sessions, which corresponds with the widget actions indicator, that measures how many actions between the widget controls (but not the embeddable editor) were performed, indicating that in the beginning (activity #1) the students needed a great deal of interaction to understand and feel comfortable with the ROLE-PLE and widgets. The mean usage of the mind-mapping tool also decreased per student from 27 minutes in activity #1 to 22 minutes for activity #4. Their interaction through Facebook for activity #1 was on average of 3 minutes only, confirming that for the activity the students mostly limited to comment to other's mind-map but not to engage in deeper discussions. Total time in the ROLE PLE also decreased from 66% of the students spent in a range between 0 and 22 minutes, to a 71% between 0 and 16 minutes for activity #4. These time contrast to mind-maps that are large in the number of nodes that were presented by the students, as will be detailed in the next section. This indicates that a considerable amount of work was performed by the students directly within the cloud-based tool and not by using the tool as widget inside the ROLE-PLE. Also mouse position movements from one widget to other widget or simply taking out the focus from the present widget were tracked, indicating that 77% of the students had changed the point between the mind-map and Facebook widget up to 54 times.

For activity #1 the CIS Analytics results were obtained for the mind map cloud-service, which the students used in order to create a map with a mean of 30 concepts. The students completed the task in a mean of 1.5 days. The analytics data show that only 33% of the students fully completed the task on time, which indicates that this very first task took them more time possibly due to the time required for getting familiar with the ROLE PLE. This activity also required to review and comment on the map of other students. The CIS Analytics shows that there is a mean of three comments per map and that each student has a mean of commenting in three maps. We

can see that the recorded discussions were not particularly long or elaborate, mainly due to time restrictions for completing the activities of the course.

In activity #4 we see a great difference between the numbers of concepts added into the maps. The most active group contributed 273 concepts, three other groups in the middle created a mean of 108 concepts, and the rest of nine groups had a mean of 34 concepts. We can see that in general we have more elaborated mind maps in this group activity compared to activity #1, and some groups had created more detailed mind maps.

Throughout all these data analysis we have seen that students worked on these activities quite fast within the ROLE-PLE, although they also spend considerable time within the tool's website. Additionally we have seen that having more detailed requirements about the activity and the tool (such as the minimum number of ideas to put in a mind map) will lead to similar workload for all students. To take stock: we can see that the handling of a ROLE environment has to be learned which, however, goes rather quickly and does not take very much time. Moreover, the students do not use the environment exclusively. Even if a tool is offered as a widget within the environment, they might switch to its original version. Possible explanations might be that they are better acquainted with the original version or that this version offers further useful functionalities.

5 Lessons Learned

Observations of the prescribed activities and the use of the ROLE tools indicated that the participants were somewhat overtaxed with this new learning scenario. The reason being that this was a totally new setting for the participants - they had not previously used such an environment. Additionally, the type and style of the learning activities were also new to the participants. Unfortunately no time was made available to them to become acquainted with the ROLE technologies before executing the learning activities either. Consequently this was reflected in the participants' negative responses in the survey. However, their emotional reactions to the tools used in the activities do not indicate that students have negative emotions against those tools. In retrospect, it would have been better if the participants were introduced to PLEs and the ROLE tools ahead of the activities and be provided with sufficient documentation and guidance before attempting to complete the learning activities. Getting acquainted to a PLE takes some time that has to be budgeted.

In addition, it has been observed that once students get used to a given tool they will prefer to use it on its own website, rather than as a widget within the PLE. According to interviews with students, the main reason for this behaviour is primarily due to the space restrictions posed by a widget. Another less prominent reason is the ability in some cases to have access to additional functionalities within the website, which are not available in a widget. The latter is a quite interesting and new result. ROLE gives learners the freedom to define their own learning environments. This freedom, however, can also be a burden, because defining one's own environment might be a hard task: you *must* reflect on your goals and the means you want to choose to reach these goals; you must find these means (data, contents, tools, partners) and get acquainted to them; you cannot just consume the service of a teacher. In previous ROLE evaluations in test beds both in Europe and China, students were reluctant in spending much effort on designing their PLEs themselves. They asked for teacher support at least in the beginning of a course, that is, they wanted pre-defined PLEs

(that they might possibly adjust to their own needs or preferences later). However, a student has to learn how to use a pre-defined PLE, which might include widgets that are probably new to him or her. The students in previous evaluation did not complain about limited functionality – they rather asked for simplicity and a good justification why they should spend effort in learning how to use the environment. The Galileo test-bed shows that once a student got acquainted to the PLE and its widgets, she might feel that it does not only empower but also restrict her learning. She asks for additional functionality that she finds outside the environment. As an act of self-regulation, she breaks out of the learning environment that she started with and that was explicitly dedicated to self-regulated learning.

6 Conclusions and Outlook

This paper has described a test-bed of cloud-based services within a PLE. The widgets integrated in this PLE consisted of three cloud-based services, a social networking, a mind-mapping tool, and an online A complete cloud-based education environment was enabled, both at the infrastructure and at the application level.

The experiences of the authors in setting up this test-bed have shown that the technologies provided by the ROLE project enable the development a truly cloud-based PLE. Initial results from evaluating this PLE with students from three different Latin-American countries have shown that this is generally perceived as a useful learning platform. However, given the novelty of this approach, the need to provide guidance and scaffolding to new users was clearly outlined. In general, more time is required to perform this type of activities, especially the activities that are group-based. Moreover, the relation of personal information management (PIM) in individual learning and group information management (GIM) in computer-supported cooperative learning (CSCL) has to be discussed and explored in closer detail. To carry out such investigations with ROLE-based environments, further test-beds are to be implemented.

From an educational orchestration point of view, the possibility to include and manage several cloud-based tools, and setting learning paths with them opens a large set of opportunities for enhancing and expanding the construction of learning experiences. What still remain to be addressed are challenges such as: how to assure the learning path will be followed and the student will not get lost, confused or distracted in the cloud-service; find the most effective ways to snapshot an assignment from students in order to meet assignment delivery deadlines.

Further improvement to cloud-based tools analytics is required by extensively test current ontologies, which may require some further enhancements for better analytics.

The CIS architecture was proven to be a key component to allow interoperability between cloud-services and learning environments such as the ROLE PLE. Some foreseen enhancements include automatic service composition for improving interoperability and inclusion of a templating system for building user interfaces and more tailored learning path.

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