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Integrating Learning Services in the Cloud: An Approach that Benefits Both Systems and Learning

Gustavo Gutiérrez-Carreón[1,3*], Thanasis Daradoumis[1,2] and Josep Jorba[1]
[1]Open University of Catalonia, Av. Tibidabo 39-43 - 08035 Barcelona, Spain // [2]University of the Aegean, University Hill, 81100, Mytilene, Greece // [3]Universidad Michoacana de San Nicolas de Hidalgo, Francisco J. Mújica S/N, Morelia, Michoacan, Mexico // ggutierrezc@uoc.edu // adaradoumis.uoc.edu // jjorbae@uoc.edu
[*]Corresponding author

ABSTRACT

Currently there is an increasing trend to implement functionalities that allow for the development of applications based on Cloud computing. In education there are high expectations for Learning Management Systems since they can be powerful tools to foster more effective collaboration within a virtual classroom. Tools can also be integrated with these systems that can provide assistance to students on any topic covered in class through the proliferation and popularity of publicly available Web APIs. However, generally most students and teachers still face technological barriers to access these resources and integrate them into their educational systems. This paper discusses an effort to overcome this problem by proposing a method of resource access through linked data, which is explicitly defined with semantic annotations related to the learning environment. Doing so, we are able to decorate the Cloud providers API's, thus providing easy integration into learning applications and important benefits for learning. The effectiveness of our approach has been measured and evaluated through usability methods and cognitive load theory principles.

Keywords

Cloud computing, Semantic web, Learning service, Usability, Cognitive load

Introduction

Cloud computing is a distributed computing paradigm under several service models (Linthicum, 2009). The Software as a Service model (SaaS) is a software and data related delivery model, where data is centrally hosted on the Cloud as a service. Under a public Cloud deployment (Baun et al., 2011), the services are offered by subscription and accessed over the Internet. The private Cloud (Rosenberg & Mateos, 2011) enables organizations to build and maintain data centers at low costs, implement new systems quickly and easily, provide resources elastically and reducing the need for organizations to maintain a large IT staff or infrastructure. In education, Cloud computing technology (and the construction of platforms for college education management) can improve the utilization resource rate, saving university resources and improving teaching level. It can also bring new areas of application closer to real life problems and study areas (Dong et al., 2012). Each type of Cloud has some kind of Application Program Interface (API), called Cloud Service API (Morel et al., 2011), that can be used to provide resources, configure, control and release them when no longer needed.

Vaquero (2011) presents an evaluation of the real benefits of Cloud computing for a course on networks using Cloud PaaS (Platform as a Service) and IaaS (Infrastructure as a Service). The results show that the introduction of Cloud technology is adequate to maintain students' attention and save time in the tasks related to the use of technologies to support education. However the same results show that the use of Cloud technology and levels of abstraction "per se" are not enough to help motivate students neither provide any considerable improvement as regards the results obtained or the acquisition of new knowledge. In this sense, the use of Cloud technology cannot be oblivious to learning objectives. Instead, it must be integrated with certain educational methodologies so that it makes a real difference in student-centered learning activities. For instance, this study showed that the use of technology "per se" does not generate the expected benefits in students' outcomes, but when this technology is used to foster activities that include collaboration, interaction, and monitoring of student progress, amongst others, the outcomes are better. In this regard, Manro et al. (2011) highlight how Cloud computing can be used to solve educational problems. This is especially true for tools that use the SaaS model, such as Facebook and Twitter or SaaS providers such as Google Apps, which is the Cloud scheme that most universities are already implementing. Similarly, this study mentioned some general benefits that the use of Cloud tools may have on university-level learning, but it has not discussed how these tools can be used in conjunction with e-learning applications or LMS and, most importantly, whether this integration may have specific benefits to both learning and teaching.

Given the prevalence of Cloud-based services in students' and faculty's personal lives, it is without a doubt necessary to consider ways in which these can be combined for the purposes of teaching and learning. It is therefore relevant to investigate how Cloud-based services can be used for pedagogy.

Our work takes the promise of Cloud and their models like SaaS a step further, which substantially benefits the development of learning systems. This is made possible by simplifying the use of the functionality provided by each Cloud Service API and integrating it to the educational environment in an easier and more flexible way. To achieve it, this paper proposes a semantic mechanism for integrating a Cloud service API with an educational system. In fact, we focus on issues related to usability (Hollender et al., 2010) and Cognitive Load Theory – CLT (Plass et al., 2010) that have to be taken into account in a holistic way. This approach is followed in order to determine whether our proposed solution for integrating learning services in the Cloud can benefit both systems and learning. On the one hand, it is the basic assertion of CLT that any instructional design needs to take the limitations of working memory into account in order to prevent an overload of working memory capacity and hence a deterioration of learning. On the other hand, usability is defined as the extent to which a user can fulfill a task using a tool effectively, efficiently, and with satisfaction; moreover, the level of the usability of a tool or application can be defined only in the context of its specific users and the specific tasks that are to be accomplished. To get to this point, first we discuss related work and then we present an approach that discusses how technologies can support semantic web and Cloud computing-based services. Subsequently, a case study related with the integration of Google Apps with Chamilo (Maes, 2010) Learning Management System (LMS) through semantic description of services is presented. Then, we discuss the results of its implementation. We conclude with suggestions for future research.

Related work

There are some related efforts to the design and development of learning systems that take advantage of the features and benefits provided by Cloud computing.

First, virtualization efforts try to create learning environments more cost effectively without compromising the level of service or user experience. Such an example is presented by Hu et al. (2011), where a successful change of the use and payment patterns for a Web-based virtual learning environment and pedagogical software was achieved through virtualization and SaaS enablement of web services. There are also efforts that demonstrate the efficiency and effectiveness of services collaboration in the Cloud. This is the case of AMBAR-C (Awareness-based learning Model for distriButive collaborative enviRonment) (Paletta and Herrero, 2010), a collaboration model used for a multi-agent based system in collaborative Cloud computing environments. In the area of micro-learning applications development, mobile services have a great potential in supporting informal learning processes. Kovachev et al. (2011), propose a tool that makes use of Cloud services to promote ubiquitous learning.

All these learning systems try to take full advantage of Cloud computing for the development of learning systems, but we see that the integration of existing learning tools with functionalities available from Cloud providers presents several problems and limitations, especially those based on SaaS. Such integration is important because it facilitates the definition of Cloud services' APIs. The next section presents the main objective and research questions of this study. It is followed by a description of the approach and discusses how technologies can support the integration of e-learning systems and Cloud services when partly based on the Semantic Web.

Objectives and contribution

Despite the efforts made in related research work, it is not yet clear how the integration of Cloud computing-based services can benefit both e-learning systems and students' learning processes. Consequently, the aim of this study it to explore the workability of a semantic description method which, on the one hand, defines the characteristics of learning services using terms that are more closely related to the educational field, thus facilitating the integration of Chamilo LMS with Cloud services. On the other hand, it wants to ensure benefits for students in terms of usability issues and cognitive overhead/load. To achieve the latter objective and test the effectiveness of the proposed approach, we set the following research questions:

- Is there a significant difference between the cognitive load-satisfaction of the students who learn with an LMS integrated with Cloud services and the students that manually access to both systems separately?
- Is there an acceptable System Usability Scale (SUS) from students who learn following the LMS integrated with Cloud services compared to those students that use independent systems?

Our study showed that the integrated system, in which Cloud services and the LMS are used as one seamless system, is more desirable and user-friendly, whereas it proved to be less strenuous on students' cognitive loads.

An approach to integrate Cloud services with e-learning systems across linked data

With an ever-increasing list of services that are provided through the Cloud, many critical applications will be deployed and consumed through SaaS mechanisms in the near future.. However, as with any new technology, the concepts of SaaS and the Cloud have limitations and problems, especially those related with the integration of applications and data sources. Integration has been an important subject of study and research which seek to determine how integration brings a sense of order out of the chaos and disorder created by heterogeneous systems, networks and services (Raj, 2011).

The service-oriented architecture (SOA) was conceived as an architectural meta-model at a higher abstraction level to the technologies that are used to implement it. SOA is currently implemented using Web service technologies such as Web Service Description Language (WSDL) and Simple Object Access Protocol (SOAP). WSDL was specifically created for this purpose, to provide several constructions which are useful to services through an XML schema, including those that describe the service operations and methods, the parameter descriptions as well as the information about the type of Protocol which is necessary to invoke the service. Figure 1 illustrates the basic interactions between the service provider, services requester and services directory for dynamic binding of services at runtime (Baun et al., 2011). In particular, a service requester (consumer) can locate a suitable service in a service directory. If a suitable service has been found, the service consumer receives a reference for accessing the service. Then, the service can be called. The service provider replies by sending a message back. Today more and more APIs are being published by the major players in the Web, such as eBay, Amazon and Google. Web applications that consume these APIs are collectively referred as mashups, and they offer interesting experience to web users.

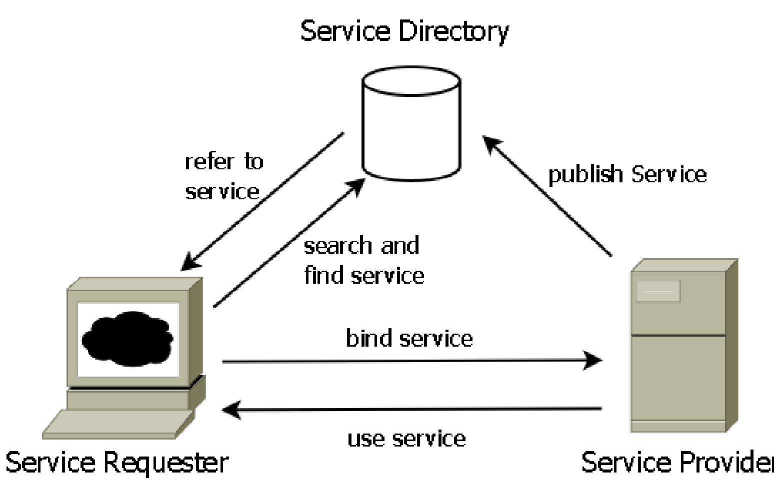
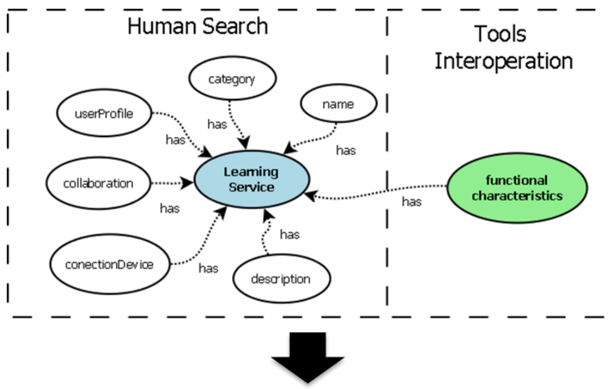


Figure 1. Service management through WSDL

However, many activities require additional features which are not caught in the specification of basic services supported by WSDL. Consequently, the so called semantic web service standards and composition languages have been defined to provide additional capabilities to service-oriented solutions that require discovery, composition, orchestration, choreography and mapping of web services. The basics of representing the Semantic Web consist of the use of two core standards: the Resource Description Framework (RDF) (Brickley & Guha, 2004) and the Web Ontology Language (OWL) (Allemang & Hendler, 2011). Additionally, linked data (Hogan et al., 2012) refers to data published on the web in such a way that it is machine readable, its meaning is explicitly defined, it is linked to other external datasets, and it can in turn be linked to from external datasets as well.

In the particular case of learning systems, integration problems are associated with the different understandings that may hold in the educational field and which are related to the particular characteristics of each area of instruction. The functional characteristics of a Cloud service API often do not match the needs that students and teachers may have. For example, , there may be an API that allows users to handle forms and process them, but in the educational field a teacher would try to access this functionality with the aim of providing “evaluation and feedback” to students. In that sense, we propose an alternative approach that makes use of the Semantic Web in general and the semantic description of services in particular to enrich the functional characteristics of the services or API’s with ontological domain characteristics of each area of teaching.

More specifically, given a specific teaching area, we propose to employ semantic annotations that will enable us to use the API functionality according to the ontological model used in the corresponding learning system, to let "decorate" and facilitate their integration with other tools. In this case, search is also promoted through characteristics that are common for teachers and students. Figure 2 shows a graphical representation of the semantics of a learning service, which is the result of a Cloud service API plus the semantic attributes that help us operate it and its OWL class representation.




```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:owl="http://www.w3.org/2002/07/owl#"
xmlns:LearningService="http://www.liberoeducacion.com/learningservice#"
xml:base="http://www.liberoeducacion.com/learningservice#">

<owl:Class rdf:about="http://www.liberoeducacion.com/learningservice#Name">
</owl:Class>

<owl:Class rdf:about="http://www.liberoeducacion.com/learningservice#Category">
</owl:Class>

<owl:Class rdf:about="http://www.liberoeducacion.com/learningservice#userProfile">
</owl:Class>

<owl:Class rdf:about="http://www.liberoeducacion.com/learningservice#collaboration">
</owl:Class>
.
.
.
```

Figure 2. A semantically represented learning service and its ontology in OWL

This fact does not affect or interferes with the processes of each service. In the case of search, several features facilitate the human interaction with the service, such as: a service name, a readable description, a service category, a type of collaboration that is designed for the service, a type of connection devices which can display the result of the service, and the user profiles that can access the service. As shown in Figure 3, RDF storage is fed with instances of OWL class with defined parameters contained in the description of Cloud services APIs. Subsequently these containers are exploited by mashups to get the services that meet the requirements of users. These results contain functional specifications for invoking them.

Comparing our approach with other studies, as the ones mentioned in the previous two sections, the integration of learning tools with functional Cloud services across semantic models represents significant benefits for the design of learning systems since it establishes common data containers for both applications, far from specific and rigid data models where each is defined separately. The educational impact that represents this type of innovation is that teachers are able to work with an integrated environment which facilitates the interaction between applications and thus provides them better opportunities in developing more solid and useful learning activities. Moreover, students achieve to reduce cognitive load (especially on task performance and the time to complete them) and work in a more user-friendly environment, as we demonstrate in the following sections.

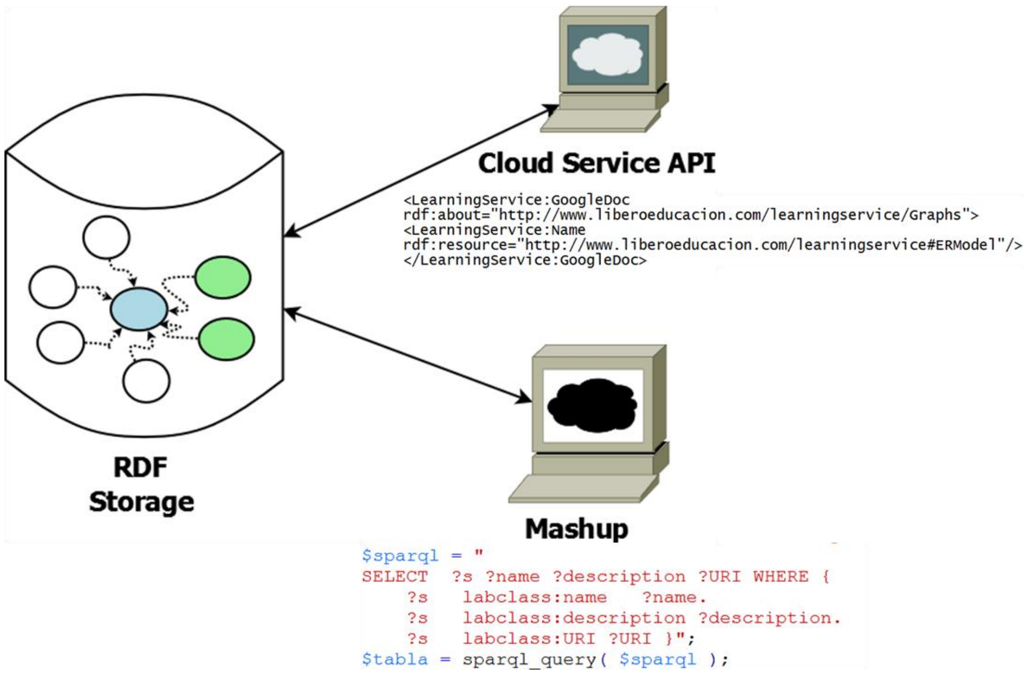


Figure 3. RDF storage fed with OWL instances and exploited with mashups

Experiment design

We have designed an experiment which deals with the integration of Google Apps Cloud features (Morel et al., 2011) within the Chamilo learning management system. In general, Chamilo supports many different kinds of learning and collaborative activities. It allows one to specify the course objectives, identify learning units, develop materials and presentations for content, build evaluation exercises and on-line tasks, while it provides assistance and collaboration tools that contain synchronous and asynchronous communication (chat and forums), as well as wikis, blogs, social networks, messages, group management, course management, recycling and more. However, instructors may have specific needs in order to meet particular objectives of a course, for example they may need a tool that is beyond the scope of Chamilo, such as a diagram designer, mail services, a document processor, etc. Such tools are offered by Google Apps and include Google Drive for storage and document creation, Youtube for audiovisual content management, Google Hangouts for handling instant electronic messaging, and live video conferencing capabilities, amongst others.

The main aim of the experiment is to develop semantic mashups to integrate the two systems using Linked data and taking advantage of the availability of APIs to interact with Google Apps.

Participants

The experiment designed above has been carried out in a class of third-year undergraduate students (N = 56) enrolled in the “Management Information Systems” course. This course is of both theoretical and practical type, and the teacher had already taught it in two previous occasions. All students have been using Chamilo as a standard tool to access course documents, submit assignments, attend meetings, and so forth. The students participated in the experience were divided into two groups: an experimental group (N = 24) and a control group (N = 32). Students in the experimental group used Chamilo integrated with Cloud services through semantic mashups and Linked data, whereas the control group was asked to access both tools separately, performing the Cloud services access manually. Both groups of students were instructed by the same teacher. The teacher assigned students specific problems to solve using the project-based learning paradigm and guided students to use Google Drive and Google Docs to share and co-construct documents, Google Groups to carry out structured discussions and Google Calendar to organize task planning and execution. The teacher provided the experimental group students with very specific indications of how and when to use each application, along with Chamilo, which definitely had a positive impact on cognitive load and usability.

Experimental procedure

1. Three 90-minute sessions over a period of two weeks were conducted, totaling 270 minutes, where all students had the chance to give a general explanation that showed how to access and use Google Apps main applications, such as: Google Drive (including Docs), Gmail, Translate, Calendar, YouTube, Sites, Hangouts, and Maps. Both experimental and control groups used Chamilo for daily course activities.

2. The learning experiment, that lasted 120 minutes, consisted of three activities that made use of Google Apps:
   - Generate a site to publish information on an assigned topic, using Google Sites.
   - Design 2 graphics to incorporate into each personal site using Google Docs.
   - Incorporate a video explaining the process of designing graphics in each personal site using YouTube.

Finally the site had to be linked to the profile of each student in the Chamilo platform. Students in the experimental group were guided to work using the semantics mashups integrated with Chamilo, while students in the control group worked on their experiment accessing Cloud services manually.

After the end of the learning experiment, all students took a usability questionnaire as well as a questionnaire that examined students' cognitive-load satisfaction.

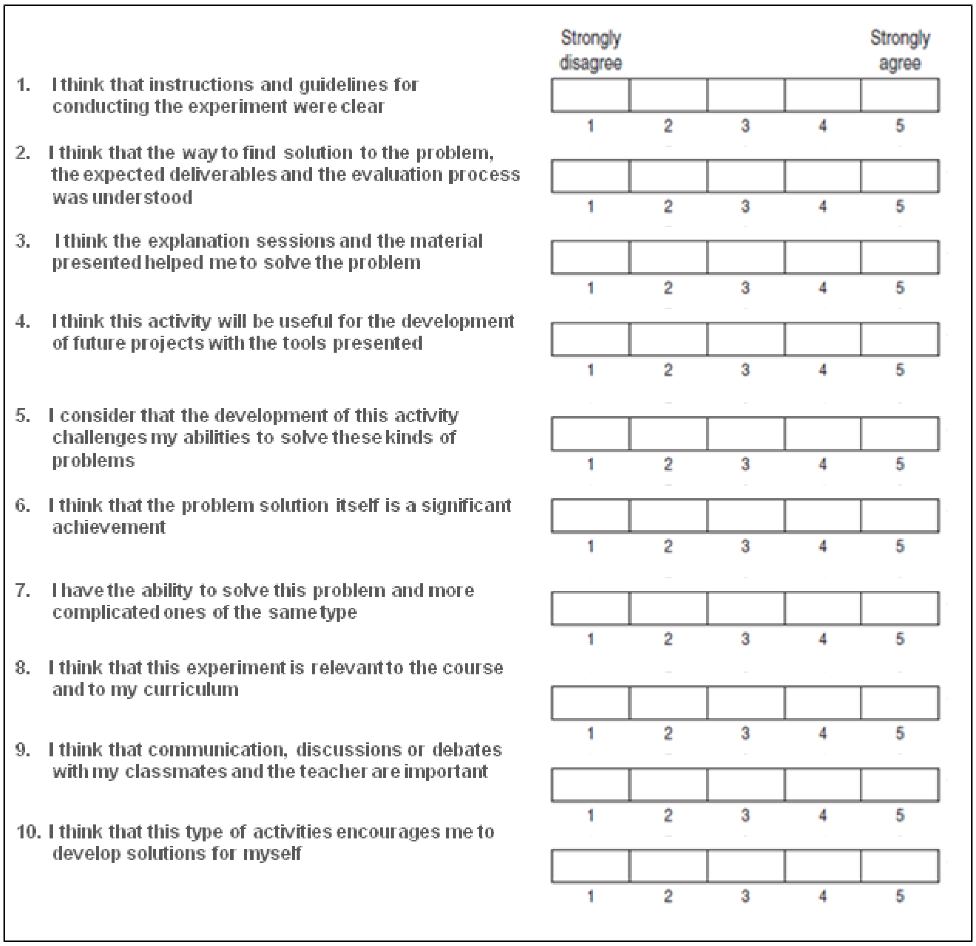
Evaluation instruments

As commented above, one of the objectives of this study is to determine the benefits that students can get from Cloud service integration with LMS. These benefits may occur at two levels: first, at cognitive load level, we examine whether students that have access to the integrated functionality have less cognitive overhead and thus focus their attention better on learning and, second, at usability level. Usability is defined as the extent to which a user can fulfill a task using a tool effectively, efficiently, and with satisfaction (ISO 9241, 1998). In fact, these two goals are interrelated, since the use of a complex educational environment that takes standard usability guidelines and principles into account may contribute to reduce extraneous cognitive load (Hollender et al. 2010). Furthermore, the applicability of existing cognitive-load educational design principles for educational software design should be evaluated empirically. It should not be assumed that Cognitive Load Theory (CLT) and its instructional design principles offer off-the-shelf solutions for educational technology.

The design and use of learning tools for online education must be done carefully when dealing with CLT issues; for instance, Wong et al (2012) found that if we assume that the cognitive load associated with the presentation of complex information could be improved by the use of animations or dual mode presentations, both forms of presentation incidentally introduce transience that also can impose a heavy cognitive load. Despite these shortcomings, there have been successful experiments, in which the consideration and evaluation of cognitive load has represented benefits to the development of learning scenarios (Schrader & Bastiaens, 2012; Moons & De Backer, 2013).

To design an instrument that allows us to evaluate and take cognitive load into account, we rely on a proposal developed by Bradford (2011), who detected a coefficient for the relationship between satisfaction and cognitive load by separating academic performance (i.e., "learning") from cognitive load and satisfaction. In this sense a survey instrument was designed, which focuses on three indicators to consider: *awareness*, *challenge* and *engagement*.

A survey of 10 items was implemented with a 5-point Likert scale. As concerns the *awareness* indicator, four questions were posed to examine whether syllabus and assignment directions were clear, problems were easy to comprehend, supporting materials were helpful, and activities were useful for new cases (questions 1 - 4). The fact of being aware of all these elements constitutes important means for finding solutions and organizing presentations so as to reduce high memory load and enhance student motivation. With regards to the *challenge* indicator, three questions relate the students' degree of satisfaction with the degree of challenge they face (questions 5 - 7); it is expected that when students are challenged, satisfaction may be their own reward and extra memory requirements (i.e., high cognitive load) seem to be fine. As for the *engagement* indicator, three questions were asked to relate relevance of different types of learning activities to the students' needs and goals (questions 8 - 10). Figure 4 presents the 10 questions used in the cognitive load - satisfaction questionnaire. Here we note that although a weak reliability (.49) exists, the coefficient can be provisionally accepted as a new scale, given that follow-up efforts to improve the coefficient are made.


Strongly disagree — Strongly agree

1. I think that instructions and guidelines for conducting the experiment were clear — 1 2 3 4 5
2. I think that the way to find solution to the problem, the expected deliverables and the evaluation process was understood — 1 2 3 4 5
3. I think the explanation sessions and the material presented helped me to solve the problem — 1 2 3 4 5
4. I think this activity will be useful for the development of future projects with the tools presented — 1 2 3 4 5
5. I consider that the development of this activity challenges my abilities to solve these kinds of problems — 1 2 3 4 5
6. I think that the problem solution itself is a significant achievement — 1 2 3 4 5
7. I have the ability to solve this problem and more complicated ones of the same type — 1 2 3 4 5
8. I think that this experiment is relevant to the course and to my curriculum — 1 2 3 4 5
9. I think that communication, discussions or debates with my classmates and the teacher are important — 1 2 3 4 5
10. I think that this type of activities encourages me to develop solutions for myself — 1 2 3 4 5

Figure 4. Questionnaire that examines the relationship of cognitive load – satisfaction

With regard to the second goal, namely the evaluation of usability issues, we asked students to respond to a usability questionnaire, called System Usability Scale (*SUS*). *SUS* is a simple, ten-item attitude 5 point Likert scale (ranging from 1-'strongly disagree' to 5 - 'strongly agree'), giving a global view of subjective assessments of usability. It was developed by Brooke (1996) and its validity has been tested by numerous studies both in several websites and Learning Management Systems as well as in other environments, such as mobile ones. It proved to produce very reliable outcomes in relation to other questionnaires, even for a small *(N = 12-15*) sample of participants (Tullis and Stetson 2004). It yields a single score on a scale of 0–100. Extensive studies with the participation of almost 2300 users confirmed that the mean evaluation value has been 70, whereas the top 25% of all scores was measured at 77.8 (Bangor et al. 2008; Bangor et al. 2009). In particular, Bangor et al. (2008) showed the following qualitative interpretation of *SUS* scores:

- *SUS* = 51 => Poor/OK
- *SUS* = 72 => Acceptable/Good
- *SUS* = 85 => Excellent

Figure 5 shows this in more detail.

Adjective	Count	Mean SUS Score	Standard Deviation
Worst Imaginable	4	12.5	13.1
Awful	22	20.3	11.3
Poor	72	35.7	12.6
OK	211	50.9	13.8
Good	345	71.4	11.6
Excellent	289	85.5	10.4
Best Imaginable	16	90.9	13.4

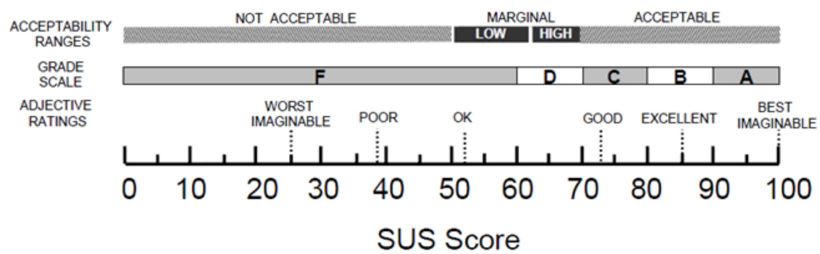
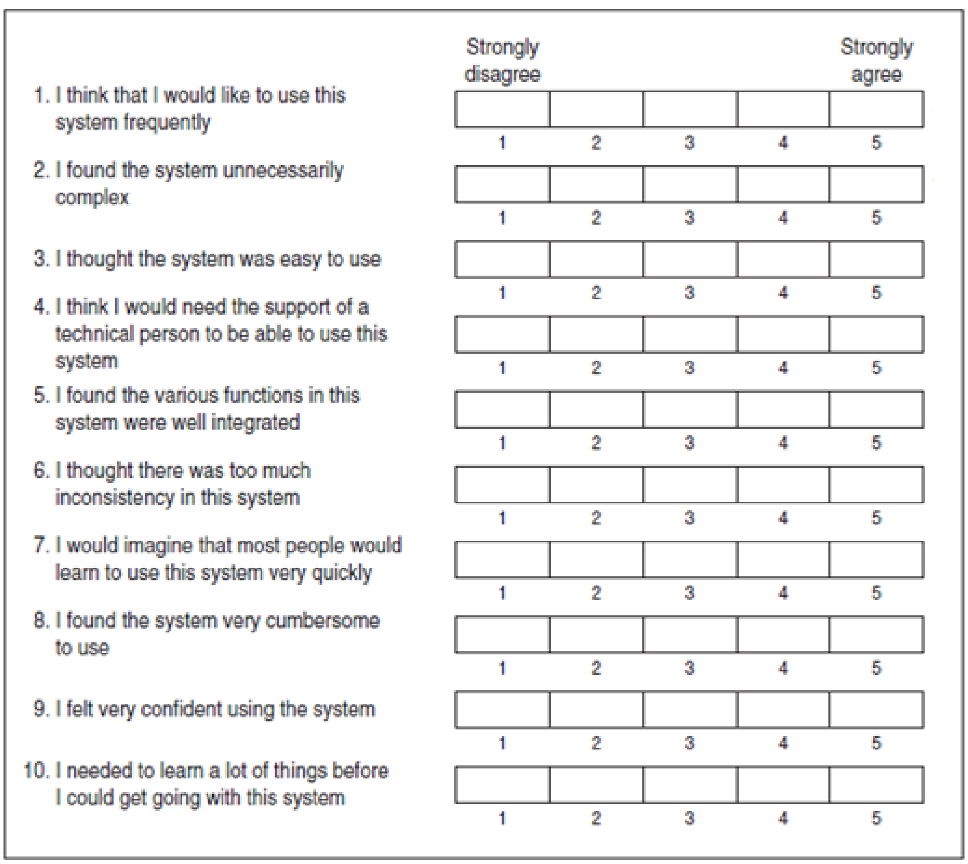


Figure 5. SUS Adjective rating - by Bangor et al. (2009)



	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Figure 6. The System Usability Scale (SUS) questionnaire

Finally, Tullis and Albert (2008), after conducting 129 studies, concluded that a score greater than 81.2 implies ranking at the top 10%. They also found that a score greater than 80 implies an increased likelihood of returning to the website and recommending it to a friend or acquaintance.

Figure 6 presents the 10 questions used in the SUS questionnaire. From the 10 questions, 5 are positively-worded and 5 are negatively-worded, alternating each positive with a negative question; by alternating positive and negative items, the respondent has to read each statement and make an effort to think whether they agree or disagree with it.

To calculate the *SUS* score, we first sum the score contributions from each item. Each item's score contribution will range from 0 to 4. So, for items 1,3,5,7 and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Finally, we multiply the sum of the scores by 2.5 to obtain the overall value of *SUS* in the range of 0 to 100.

Presentation and significance of the results

After students completed the experiment, they were asked to answer the two questionnaires presented above. The first questionnaire assessed the relationship between satisfaction and cognitive load that students experienced while trying to perform the activities of the experiment. The second questionnaire evaluated the students' experience in terms of usability of the tool. The descriptive statistical analysis includes the mean, median, mode, standard deviation, variance, skewness, kurtosis, range, maximum, minimum, and sum of the response to each question. These statistics provide an overview of the students' responses to the questionnaire. The values of the responses are those of a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), so they are discrete values used to provide basic statistical calculations such as the mean, standard deviation, variance, skewness and kurtosis, which reflect the trend of values of the responses and the shape of a probability distribution, without representing themselves a specific value within the scale. The case of values, such as mode, median, minimum value, maximum value, sum and range, shows the values of the options in which students responded, giving us a breakdown of the options selected in each response.

The results of the first questionnaire are presented in Tables 1 and 2 below, which reflect a statistical profile of the students' answers to each of the questions for both the control and the experimental group. In general, in each of the evaluation criteria, the results of the experimental group were closer to strongly agree compared to the same results of the control group. In particular, to determine the relationship between cognitive load and satisfaction, we examined the three indicators defined above: *awareness*, *challenge* and *engagement.*

Table 1. Descriptive statistics estimated for the control group

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
N	32	32	32	32	32	32	32	32	32	32
Mean	3.6875	4.0000	3.8438	4.0625	4.1250	4.2188	3.9375	3.9063	3.9688	3.8438
SE of the mean	.1980	.1619	.1355	.1551	.1838	.1471	.1485	.1701	.1823	.1563
Median	3.5000	4.0000	4.0000	4.0000	5.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Mode	3.00	5.00	4.00	5.00	5.00	5.00	4.00	5.00	5.00	3.00
Standard deviation	1.1198	.9158	.7666	.8776	1.0395	.8322	.8400	.9625	1.0313	.8839
Variance	1.2540	.8387	.5877	.7702	1.0806	.6925	.7056	.9264	1.0635	.7813
Skewness	-.063	-.269	-.179	-.432	-.632	-.801	-.226	-.266	-.499	.024
Kurtosis	-1.429	-1.199	-.270	-.834	-1.129	-.007	-.757	-1.083	-1.001	-1.150
Range	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Minimum	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Sum	118.00	128.00	123.00	130.00	132.00	135.00	126.00	125.00	127.00	123.00

In the case of the *awareness* indicator (questions 1 - 4), based on the responses of each of the groups, we can determine that the experimental group showed a better performance for finding solutions and organization of the presentation. We can conclude that, compared with the control group, the integrated system reduced high memory load and increased the motivation of students. As for the *challenge* indicator (questions 5 - 7), the experimental group showed a better relationship between the degree of student satisfaction and the level of challenge they face; in this case satisfaction has been students' main reward, which eases the additional memory load required, thus alleviating cognitive load and increasing students' general well-being. As concerns the *engagement* indicator (questions 8-10), the experimental group showed a better perception of the relevance of different types of learning activities with regard to the students' needs and goals, which improves the 'cognitive load – satisfaction' relationship for these students. All in all, we can conclude that students using the integrated system had significant benefits as regards the 'cognitive load- satisfaction' relationship with respect to the control group students that used Google Apps services independently.

Table 2. Descriptive statistics estimated for the experimental group

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
N	24	24	24	24	24	24	24	24	24	24
Mean	4.6250	4.6250	4.2500	4.6667	4.3750	4.6250	4.5417	4.6250	4.6250	4.7083
SE of the mean	.1009	.1009	.1241	9.8E-02	.1320	.1009	.1039	.1009	.1009	9.4E-02
Median	5.0000	5.0000	4.0000	5.0000	4.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Mode	5.00	5.00	4.00	5.00	4.00	5.00	5.00	5.00	5.00	5.00
Standard deviation	.4945	.4945	.6079	.4815	.6469	.4945	.5090	.4945	.4945	.4643
Variance	.2446	.2446	.3696	.2319	.4185	.2446	.2591	.2446	.2446	.2156
Skewness	-.551	-.551	-.158	-.755	-.542	-.551	-.179	-.551	-.551	-.979
Kurtosis	-1.859	-1.859	-.347	-1.568	-.519	-1.859	-2.156	-1.859	-1.859	-1.145
Range	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
Minimum	4.00	4.00	3.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Sum	111.00	111.00	102.00	112.00	105.00	111.00	109.00	111.00	111.00	113.00

In addition to the questionnaire responses of Tables 1 and 2 that correspond to a Likert scale with discrete response values ranging from 1 to 5, we considered useful to include frequency tables which show the number (and percentage) of students who answered each of the options (1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree) associated with each question. Tables 3 and 4 show the frequency tables for the responses of each question for the control and experimental groups respectively.

Table 3 shows that the results of the control group fluctuate between the values of 2 representing disagree, to 5 representing totally agree, and are divided into thirds responses between options 3, 4 and 5. In the case of the experimental group, Table 4 shows that values range from 3- neutral to 5- strongly agree and the answers are divided into halves on value 4 corresponding to agree and value 5 corresponding to strongly agree. From these results we can highlight some points that indicate that the LMS tool integrated with Cloud services is more useful and effective for the students in the experimental group and, in fact, improves the cognitive load-satisfaction relationship. As a general comment, we can see that in the majority of questions (8 out of 10), all the students (100%) of the experimental group have a positive attitude (i.e., agree or strongly agree). There are only 2 questions (Q3 and Q5) with a few (8.3%) neutral responses. In contrast, students in the control group were not so positive. Even in some instances they expressed disagreement. For example, while in Q1 100% of the experimental group students agree or strongly agree that the instructions and guidelines were clear, only 50% do so in the control group, with 15.6% of students showing disagreement. Similarly, in Q4 only 37.5% of the control group students strongly agree that the knowledge acquired in the experiment will be useful in future projects, against 66.7% in the experimental group, which clearly shows the higher level of satisfaction of the experimental group students. Finally, in Q10 the experimental group shows more confidence to develop these kinds of projects with 70.8% strongly agree against only 28.1% of the control group.

Finally, we performed the reliability measure of the Cognitive Load instrument based on Cronbach's alpha which considers as acceptable value a coefficient around 0.8. Table 5 shows the results for the binding coefficient of the experimental and control groups, as well as their independent values. The results demonstrate that the reliability of the instrument used is quite good in all cases, showing a clear consistency in the case of the experimental group. As a conclusion, the instrument used to address our first research question (i.e., the difference between the cognitive load-satisfaction of the students who learn with an LMS integrated with Cloud services and the students that manually access to both systems separately) proves to be reliable.

Table 3. Frequency table for the control group

Likert scale	2		3		4		5		Total	
	F	%	*F*	%	*F*	%	*F*	%	*F*	%
Q1	5	15.6	11	34.4	5	15.6	11	34.4	32	100
Q2	1	3.1	10	31.3	9	28.1	12	37.5	32	100
Q3	1	3.1	9	28.1	16	50.0	6	18.8	32	100
Q4	1	3.1	8	25.0	11	34.4	12	37.5	32	100
Q5	2	6.3	9	28.1	4	12.5	17	53.1	32	100
Q6	1	3.1	5	15.6	12	37.5	14	43.8	32	100
Q7	1	3.1	9	28.1	13	40.6	9	28.1	32	100
Q8	2	6.3	10	31.3	9	28.1	11	34.4	32	100
Q9	3	9.4	8	25.0	8	25.0	13	40.6	32	100
Q10	1	3.1	12	37.5	10	31.5	9	28.1	32	100

Note. F – Frequency. % – Percentage.

Table 4. Frequency table for experimental group

Likert scale	3		4		5		Total	
	F	%	*F*	%	*F*	%	*F*	%
Q1	0	0	9	37.5	15	62.5	24	100
Q2	0	0	9	37.5	15	62.5	24	100
Q3	2	8.3	14	58.3	8	33.3	24	100
Q4	0	0	8	33.3	16	66.7	24	100
Q5	2	8.3	11	45.8	11	45.8	24	100
Q6	0	0	9	37.5	15	62.5	24	100
Q7	0	0	11	45.8	13	54.2	24	100
Q8	0	0	9	37.5	15	62.5	24	100
Q9	0	0	9	37.5	15	62.5	24	100
Q10	0	0	7	29.2	17	70.8	24	100

Note. F – Frequency. % – Percentage.

Table 5. Reliability of Cognitive Load instrument based on the Cronbach's alpha

	Control and experimental	Control	Experimental
Cronbach's alpha	.8604	.7704	.9040

In the case of usability, the analysis reflects the mean *SUS* score (*M*) for each one of the groups (Table 6). In particular, the mean SUS score is shown for each group, which can be considered acceptable (*SUS > 70*) for both groups, being in the case of the control group on the grade scale of "good" (*SUS > 70*) and in the case of the experimental group on the grade scale near "excellent" (*SUS > 80*). Comparing these usability values, we can see that the usability of the integrated system (LMS endowed with Cloud services) built through our semantic description method is further improved, which allows students to have a more satisfying experience in the educational scenario they participated in terms of usability.

Table 6. Result value of SUS for Control Group and Experimental Group

Control Group					Experimental Group				
n	*max*	*Min*	*M*	*SD*	*n*	*max*	*min*	*M*	*SD*
32	95	57.5	76	8.25	24	95	75	83.3	8.82

Note. *n* = students; *max* = maximum value; *min* = minimum value; *M* = Mean; *SD* = standard deviation.

Findings: Response to the research questions

Based on the above results, we can provide solid responses to the two research questions set in the beginning of this paper. In the case of cognitive load / satisfaction relationship, we can argue that the experimental group has better results for the indicators of *awareness*, *challenge* and *engagement* than the control group. For each of the questions related to these indicators, the control group students describe their experience as less satisfactory with respect to the experimental group that used the integrated system. Students' satisfaction in the experimental group has, in turn, a positive impact on cognitive load and subsequently on their learning. Furthermore, with regard to usability, both groups consider the development of the experiment as an acceptable experience, though the experimental group expresses greater satisfaction. From these results we can conclude that an LMS integrated with Cloud services is more acceptable and useful than one in which users have to use them as separate tools.

Conclusions and future work

In this paper we have shown the benefits that users can obtain from exploiting the integration capabilities between an LMS and Cloud services by means of a semantic model. On the one hand, we showed how an LMS that integrates with Cloud services, built out of a semantic description method, has a direct positive impact on students' cognitive load by reducing it and thus increasing students' satisfaction levels. On the other hand, we highlighted how this system shows better usability than one in which tools are used independently. Future work is on the way to extend our approach by integrating more learning tools with functionalities that are available in the Cloud, applied in different learning scenarios, with the ultimate aim to provide a comparative study of all the possible benefits, advantages as well as possible limitations. In this new study we will explore the impact of integration on faculty as well, considering the barriers that faculty experience in terms of the gamut of tools that are available to them. To this end we will include factors like faculty attitudes, perceptions and experiences as well as how LMS and Cloud-computing can help facilitate cost-effective, innovative solutions for Higher Education.

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