A Study of Virtual Learning Environments

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Abstract: - This paper analyzes several features of virtual learning environments. These tools are basic for new models of education because their basic idea is to reduce the number of hours face-to-face in the classroom and to promote remote individual work. This is the main purpose of the new European models given by the Bologna process. Four studies have been made. First of them, shows level of popularity of each environment according number of entrances in two web searchers. From this previous study, we have chosen the most popular environments and we will give the details of their features and main differences between them. We are going analyze existing environments to create online learning communities and so, promoting online learning. Next, we will show a study this type of educational social software. This study involves a questionnaire to some lecturers of our university, Polytechnic University of Valencia. Our analysis presents most important results. Then, we have studied the virtual learning environments used in the Spanish universities. It will show us which of them are more used in Spain. Finally in the last part of the paper, we will show a performance evaluation of the two main environments.

Key-Words: - LMS, e-learning, Virtual learning environment, educational environments, LCMS, CMS.

1 Introduction

The word e-learning (electronic learning) defines a type of learning based on information and communication technologies. This way to learn makes easier to create, adopt and distribute contents. Independently of time-limit or geographical limits, this way allows students exchange opinions and information by ICT (Information and Communication Technologies).

There are many tools to compose this new educational strategy; however some of them are remarkable: utilities to present contents (texts, animations, graphics, videos…), tools for asynchronous or synchronous communication between students and teachers like for example, e-mail, chat, forums, blogs, wikis…

In short, e-learning can be traduced by "virtual learning". It is a software system designed to support teaching and learning that allows tutors and learners to interact in an integrated, on-line environment. It is used for remote education through the World Wide Web [1]. This type of learning is based on telematic networks where students are usually connected to Internet.

An e-learning solution is built by three basic components: the platform, the contents and the communication tools.

The platform is the hardware and software environment designed to automate and manage development academic formation activities. It is known as online platform or LMS (Learning Management System) [2]. A LMS is a software program installed in a server and it is used to administer, distribute and check activities for face-to-face formation o e-learning in an organization. The main functions of a LMS are: manage and register users, resources and formation activities, access check, control and monitoring learning process, doing evaluations, informs, managing communication services like forums and teleconference amongst others. Generally, a LMS doesn't include possibilities to create its own contents, but it is in charge of administrating contents created by different sources.

A LCMS (Learning Content Management Systems) is used to create contents for courses [3]. Most of LMSs work using web servers in order to be accessible through Internet [4].

Regarding contents, the quality is a necessary condition, although it is not sufficient condition for a successful formation programs. The design of contents should be done by experts on didactic methodology and, taking into account this idea, contents ought to be designed using the following characteristics:

- Adjustment to the necessities and possibilities of the pupils
- Quality and quantity of the information presented
- Interactive
- Appropriate structure for its good and easy assimilation

Then, the content has to be related in the platform. Metadata provides means to organize the content of e-Learning courses and to visualize the semantic connections between concepts. It is possible to extend and reuse metadata specifications by utilizing ontologies and ontology languages and markup languages for e-Learning [5].

In this point, we have a platform and content but; can we run an online course only with these elements? The answer is negative. Communication tools are a fundamental part in this academic environment. They allow interaction between different agents of learning-teaching process. The interaction aforementioned is necessary to do work groups, exchanging experiences, providing help by a tutor, resolving doubts, etc.

There are two groups of tools depending on whether or not the communication is in real time:

- Communication synchronous tools: telephone, chat, webcam, videoconference, electronic blackboard, shared online documents.
- Communication asynchronous tools: they are basic for an e-learning environment ("anytime, anywhere"). Forums, groups of news, e-mail and nowadays, blogs and wikis.

Through the years Virtual learning environments have evolved giving several generations of platforms [6]. Last tendencies in virtual learning environment are collaborative platforms. They provide many benefits to the students [7, 8].

If we base our classification in free code e-learning platforms we can choose between: ATutor, Bodington, Claroline, Dokeos, KEWL, ILIAS, .LRN, LON-CAPA, Moodle, Sakai Project, LogiCampus, etc [9]. We can also find commercials e-learning platforms such as: NetCampus, Angel Learning, VerticeLearning, Blackboard, WebCT, e-ducativa, Scholar360, FirstClass and Desire2Learn and many more [10, 11].

There are several Virtual Learning Environment studies and comparisons in the literature. Some of them were performed to compare the functionality and the functional characteristics of these platforms [12] and others compare the number of services offered [13], but none of them have compared their popularity in the World Wide Web, none of them have presented a performance comparison between Moodle and Sakai and there is not any publication with the type of Virtual Learning Environments used in the Spanish Universities.

This paper is structured in five sections. Section 2 will give the details of some platforms that we have decided to explain after a previous analysis. In section 3, we compare the platforms aforementioned at a technical level. In section 4, we will explain the questionnaire sent to the university lecturers. We have used them to do the study about the platforms based on their opinions about this type of educational software, which have been analyzed and discussed in section 5. Section 6 shows the virtual learning environments used in the Spanish Universities. A performance test comparison between Moodle and Sakai is shown in section 7. Conclusions are summarized in the section 8.

2 Description and study of educational platforms

This study is useful to decide what platforms of all platforms aforementioned are the best for our research. This study shows us which of them are more cited on Internet. Platforms with major impact factor, deduced from the popularity parameter, will be studied and analyzed. The popularity parameter has been measured from the number of entrances in two different web searchers. We have based on the following relation: the more times is mentioned a term by a web searcher the more impact it has. So, it is more famous.

The web searchers used to perform our study have been Google and Yahoo search engines, because they are the most popular searchers at this moment.

We can see in figure 1, that the most famous platforms are: in the first place, Moodle (much more advanced than others), in second place, the mix of WebCT and Blackboard and, in third place, Sakai according to Yahoo and Dokeos according to Google. We have considered analyze Moodle, Blackboard/ WebCT and Sakai. We have opted for Sakai because of its impact and present expansion.

2.1 Moodle

Moodle is a course management system (CMS); a free package designed using known pedagogical principles to help the educators to create effective online learning communities.

Moodle is provided freely as Open Source software under the GNU Public License. This means Moodle is copyrighted, but you are allowed to copy, use and modify Moodle provided that you agree to: provide the source to others; not modify or remove the original license and copyrights, and apply this same license to any derivative work.

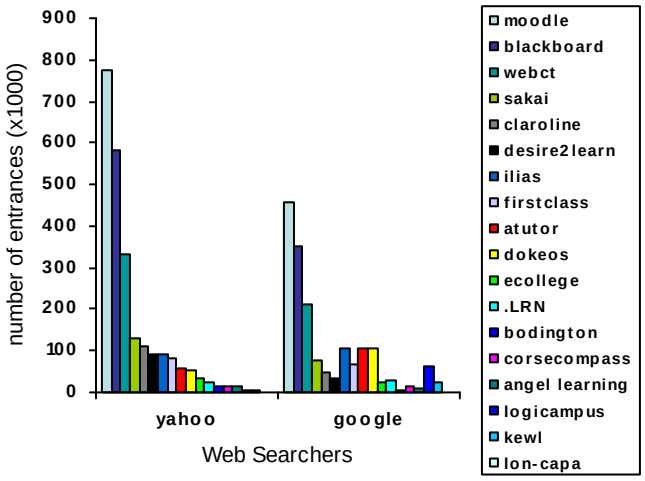

Figure 1. Comparative of platforms

Moodle can be installed on any computer that can run PHP, and can support a SQL type database (e.g. MySQL).

It can run on Windows and Mac operating systems and many distributions of linux (e.g. Red Hat or Debian GNU). There are many Moodle Partners to assist you, even to host your Moodle site.

The word Moodle was originally an acronym for Modular Object-Oriented Dynamic Learning Environment, which is mostly useful to programmers and education theorists.

Moodle is an active and evolving work in progress. Its development was started by Martin Dougiamas, a system administrator of WebCT installation in Curtin University of Technology, who continues to lead the project [14].

The main characteristics of this platform are:

- Promotes social constructionist pedagogy (collaboration, activities, critical reflection, etc).
- Suitable for 100% online classes as well as supplementing face-to-face learning.
- Simple, lightweight, efficient, compatible, low-tech browser interface.
- Easy to install on almost any platform that supports PHP. Requires only one database that it is shared.
- Full database abstraction supports all major brands of database (except for initial table definition).
- Course listing shows descriptions for every course on the server, including accessibility to guests.
- Courses can be categorised and searched, one Moodle site can support thousands of courses.
- Emphasis on strong security throughout. Forms are all checked, data validated, cookies encrypted etc.
- Most text entry areas (resources, forum postings etc) can be edited using an embedded WYSIWYG HTML editor.

It has three types of management: site management, user management, and course management, and it has several modules to improve interaction between users: assignment module, chat module, choice module, forum module, glossary module, lesson module, quiz module, resource module, survey module, wiki module and workshop module.

Moodle has a large and diverse user community with over 330,000 registered users only in http://moodle.org, speaking over 70 languages in 196 countries [15].

2.2 Sakai

Sakai is a free and open source product that is built and maintained by the Sakai community. Sakai's development model is called "Community Source" because many of the developers creating Sakai are drawn from the "community" of organizations that have adopted and are using Sakai.

Sakai is an online Collaboration and Learning Environment. Many users of Sakai deploy it to support teaching and learning, ad hoc group collaboration, support for portfolios and research collaboration.

Sakai is a set of software tools designed to help instructors, researchers and students to create websites on the web. For coursework, Sakai provides features to supplement and enhance teaching and learning.

For collaboration, Sakai has several tools to help to organize communication and collaborative work on campus and around the world. Using a web browser, users choose from Sakai's tools to create a site that meets their needs. To use Sakai, no knowledge of HTML is necessary. Here are some examples of websites made with Sakai:

- A worksite where an instructor or project director can make announcements and share resources, such as electronic documents or links to other websites.
- A worksite that serves as an online discussion board.
- A course worksite where students can work on and submit assignments electronically.

The Sakai Project was founded in University of Michigan and Indiana University. Later MIT and Stanford Universities joined them, together with Open Knowledge Initiative (OKI) and Consortium uPortal. The project was consolidated with the help of Mellon Foundation.

The aim of the Sakai Project is to create collaboration and learning environment to the higher education, so it can be competed with its similar commercials platforms (Blackboard or WebCT) or it can improve others open source solutions like Moodle.

The foundation Sakai has been created to manage the Project. More than a hundred of universities belong to the foundation. Some of them stand out for courses's number and users: Indiana University, University of Michigan, Yale University, Stanford University and Polytechnic University of Valencia.

Using a web browser, users can choose among several tools of Sakai to create a place of work appropriated to do courses, projects and research collaboration. In order to do a course, Sakai offers features to support and stimulate education and learning. To carry out team projects, Sakai has several tools to organize the communication and collaboration work in the campus and around the world.

The Sakai software has several options for communication among teachers and students, reader news RSS, distribution teaching content, to do exams, management of works, etc.

A set of generic collaboration tools forms the core of Sakai: Announcements, Drop Box, Email Archive, Resources, Chat Room, Forums, Threaded Discussion, Message Center, Message of the Day, News/RSS, Preferentes, Presentation, Profile / Roster, Repository, Search, Schedule, Search, Web Content, WebDAV, Wiki and Site Setup.

The core tools can be augmented with tools designed for a particular application of Sakai.

Teaching Tools: Assignments, Grade book, Module, Editor, QTI Authoring, QTI Assessment, Section Management, Syllabus and Portfolio Tools: Forms, Evaluations, Glossary, Matrices, Layouts, Templates, Reports and Wizards.

The Sakai community is actively developing new Sakai tools: IMS Common Cartridge, SCORM, blog tool, shared whiteboard, shared display, multipoint audio, multipoint audio, pod-casting, IMS Tool Interoperability, and others [16].

2.3 Blackboard and WebCT

WebCT (Course Tools), now owned by Blackboard and being phased out, is an online proprietary virtual learning environment system which is sold to colleges and other institutions and is used in many campuses for e-learning. Instructors could add to their WebCT courses tools such as discussion boards, mail systems and live chat, along with content such as documents and web pages.

WebCT was originally developed at the University of British Columbia by a faculty member in computer science, Murray W. Goldberg. In 1997 Goldberg created a company, WebCT Educational Technologies Corporation, a spinoff company of UBC.

In February 2006, WebCT was acquired by Blackboard Inc. As part of the merger terms with Blackboard, the WebCT name will be phased out over time in favor of the Blackboard brand.

WebCT was notable for being the first commercially successful virtual learning environment. It had long been criticized for being the most difficult of the course management systems to use. This criticism partly reflected the flexibility and power of the system - where other systems present a single way of organizing or adding course material, WebCT offered several options with more of the structure left to the individual instructor.

Blackboard Inc. is a software company based in Washington, D.C [17]. Blackboard went public in June 2004. Blackboard develops and licenses software applications and related services to over 2200 education institutions in more than 60 countries. These institutions use Blackboard software to manage e-learning, transaction processing and e-commerce, and online communities. Its product's line includes:

- The Blackboard Academic Suite, consisting of
  - The Blackboard Learning System, a course management system.
  - The Blackboard Community System, a community and portal system.
  - The Blackboard Content System, a content management system.
- The Blackboard Commerce Suite, consisting of
  - The Blackboard Transaction System, a Transaction Processing System tied to university IDs.
  - The Blackboard Community System, an e-commerce front end for the Transaction System.
  - Bb One, a network of commercial and retail business that accept Blackboard-powered debit card transactions.
- The former WebCT Inc's products, including
  - Blackboard Vista, a course management system.
  - Blackboard Campus Edition, course management system.

Though Blackboard software is closed source, the company provides an open architecture, called Building Blocks, which can be used to extend the functionality of Blackboard products. The Blackboard Vista and Campus Edition products are extensible through a technology called PowerLinks.

3 Technical comparative of platforms

Moodle and Sakai also stacks up well against the feature sets of the major commercial systems.

In Table 1, it is compared the features in the four leading commercial CMS: Moodle, Sakai Blackboard and WebCT.

Feature	Blackboard	WebCT	Moodle	Sakai
Upload and share documents	Yes	Yes	Yes	Yes
Create content online in HTML	No	Yes	Yes	Yes
Online Discussions	Yes	Yes	Yes	Yes
Grade discussions/participation	No	Yes	Yes	Yes
Online Chat	Yes	Yes	Yes	Yes
Student peer review	No	No	Yes	Yes
Online Quizzes/Surveys	Yes	Yes	Yes	Yes
Online Gradebook	Yes	Yes	Yes	Yes
Student submission of documents	Yes	Yes	Yes	Yes
Self-assessment of submission	No	No	Yes	Yes
Student Workgroups	Yes	Yes	Yes	Yes
Student journals	No	No	Yes	No
Embedded glosary	No	No	Yes	Yes

Table 1. Feature Comparison

You can see that Moodle and Sakai already has all of the major features of the commercial systems, and a few that they don't [18].

4 Questionnaire for educational platforms valuation

To know the level of knowledge of this type of learning management systems in the academic environment, we have carried out a survey with different members of the Polytechnic University of Valencia. This University uses PoliformaT, a support platform for teaching. PoliformaT is member of Sakai project and it is based on it.

The items of this survey are as follows:

1. Could you tell me if your college has educational platforms?
2. If so, Could tell me what is the platform name? (Sakai, Moodle…)
3. Can you value level of difficulty to bring up to date contents for your lessons in this platform? Where 0 is equivalent to say "Not difficult at all" and 10 to "Very difficult"
4. Can you value level of satisfaction of the following items of the platform that you use? Where 0 is equivalent to say "Not satisfied at all" and 10 to "Very satisfied".
   - Ease of use
   - Download Speed
   - Variety of contents
   - Contents quality
   - Contents update
   - Attractive design
   - Online assistance
   - Global satisfaction
5. Do you know or do you use the following online learning platforms? Angel, Blackboard, CourseCompass, Desire2Learn, eCollege, Moodle, Sakai, WebCT, ATutor, ILIAS, Dokeos, Claroline, .LRN (Dot Learn).
6. How often do you use it?
7. Can you value the degree of satisfaction of each platform that you have used. Number 0 is equivalent to "Not satisfied at all" and 10 to "Very satisfied"
8. If you aren't satisfied with the use of these systems, please, could you tell me what the main reasons are?
9. What items do you agree in the following affirmations? 0 is equivalent to say "I don't agree at all" and 10 to "I absolutely agree":
   - Teachers are in the habit of using new technologies to improve teaching quality.
   - Students are in the habit of using new technologies to achieve their studies rightly.
   - Use of technology will allow a better development for your future theoretical lessons
   - Use of technology will allow a better development for your future practice lessons
   - New virtual technologies will become fundamental for higher education
10. Which functions would you add to the platform you are usually using?
11. What contents or functions would you remove or modify because of level of difficult or useless associated?
12. To conclude, could you tell me what subjects do you teach?

5 Questionnaire results and their Analysis

In this section the obtained results are shown.

Attending to the information shown in figure 2, we can say that the 30% of the surveys haven't been answered and the 20% of the participants know nothing of these educational platforms.

The 50% remaining of the participants have answered the survey. We can conclude that the 70% of them know just two platforms, and the 30% of the participants only know the platform that they are using in the University. Sakai is the most popular in our university known by the 100% of the people, Moodle is quite known too with 60% and WebCT is the least famous with 10%. The 10% of answers consider that Moodle is much more suitable than any other platform due to its easy use, its large deployment and because it has many applications.

Everyday teachers use platforms to improve their subjects and upload new information for lessons. All the teachers bet on this type of tools and they consider them very useful to improve education and promote learning. Generally, teachers think that the level of difficulty to use them is low; it is shown in figure 3. They mark an average with two points in a set of values one to ten and, on the other hand, they mark global satisfaction with a seven.

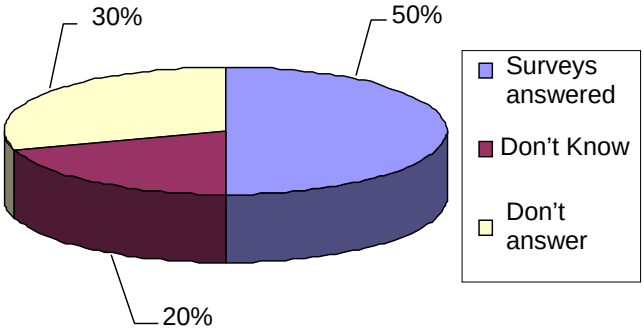

Figure 2. Percentage of surveys sent and answered

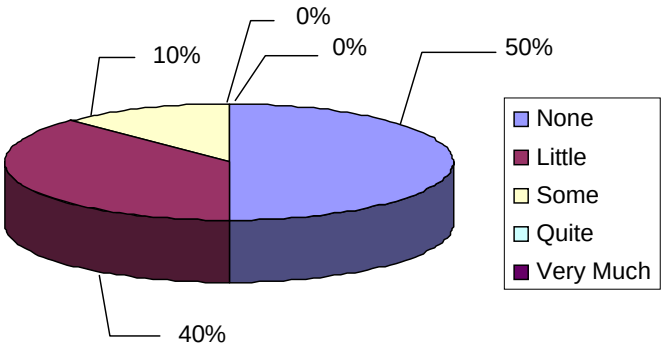

Figure 3. Difficulty to use e-learning platforms

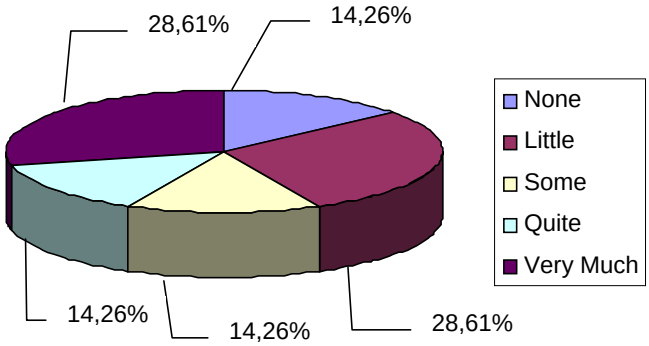

Figure 4. Habit teachers of using new e-learning technologies

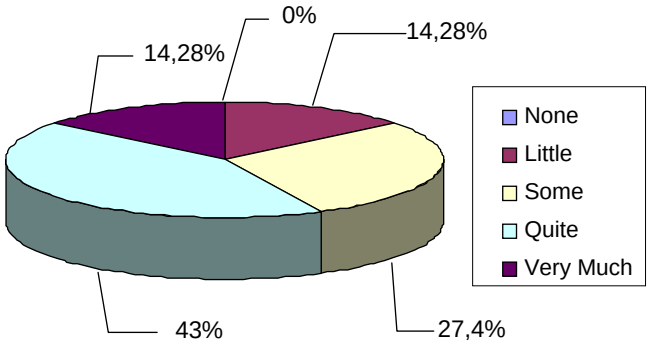

Figure 5. Habit students of using new Technologies to improve academic performance

According to the results shown in figure 4, we consider that the results are a little ambiguous with regard to the teachers's habit to use new technologies and so, improving teaching quality. There are very different answers, somebody says they are in the habit of using them and others say quite the contrary. Generally, this is like that because of the age of participants, the youngest participants are more prone to use them and elderly people considerer it more difficult. On the other hand pupils, in general, are more familiarize with new technologies to reach their studies as well (see figure 5).

In spite of that, all the teachers say that new applications can improve education system and the practices and the theoretical lessons can be reinforced and improved due to the tools that are turning up.

Teachers have contributed with some new ideas to improve these systems, e.g.: creating a similar tool to the messenger with the possibility of using webcam, possibility of adding online animations, doing more calculus with pupil's notes or doing a personal virtual tutor session.

Finally, all the teachers agree about the necessity of increasing easiness the use of these platforms and so, promoting their utilization and increasing their efficiency and dynamism. Besides, they think these systems have to be efficiency and dynamism.

6 e-learning platform used in the Spanish Universities

In this section, we are going to see which platforms are used in the Spanish universities. Some studies like ours have been published in the literature such as the one in reference [19] for the Italian universities and the one in reference [20] for the Iranian Universities

Table 2 shows our study. There are more universities in Spain that use virtual learning environments, but this table is representative enough. Besides, some universities have its own Virtual Learning Platform. Moodle has been the most used. Our conclusion is that most universities have migrated from WebCT to Moodle because WebCT is a commercial platform and Moodle is open source.

	Moodle	Sakai	WebCT	ILIAS
Universidad Politécnica de Madrid	X			
Universidad Politécnica de Valencia		X		
Universidad de Almería			X	
Universidad de Cádiz	X		X	
Universidad de Córdoba	X			
Universidad de Granada	X		X	
Universidad de Huelva	X		X	
Universidad de Jaén				X
Universidad de Málaga	X			
Universidad Pablo de Olavide			X	
Universidad de Sevilla			X	
Universidad de Zaragoza	X			
Universidad de Oviedo	X			
Universidad de la Laguna	X			
Universidad de las Palmas de Gran Canaria	X			
Universidad de salamanca	X			
Universitat de Barcelona	X		X	
Universitat de Lleida		X		
Universidad de Deusto (Bilbao)	X			

Table 2. e-learning platforms in Spain

In the next section, we are going compare the performance of two open source environments: Moodle and Sakai. Moodle is the most popular and Sakai .Both of them are open source.

7 Performance Test

We have measured the load of the servers when one or several users log into them. In figure 6 we can see the number of I/O operations during login process.

Sakai server is less loaded than Moodle one, but it takes more time to log users into the system when there are several authenticating at the same time.

Figure 7 shows the operations with data files per second when a file is uploaded to the server. In this case, the same 9 MB size pdf file has been uploaded by an administrator user to both platforms. As we can see, Sakai is more regular but it results to be slower than Moodle in this operation.

In order to evaluate the response of servers to download requests, we have made a test with the same pdf file uploaded before. Now, and like in the authentication measurements, figure 8 shows the results of two tests per server: The download of the file by a user or by four users at the same time.

Moodle gets better results when there is only one download, but when the file demand grows up the situation is very similar in both servers and Sakai serve the files faster than Moodle.

At last, figure 9 shows I/O operations when a message is uploaded to the server. Due to the small size of the file, most of the load is produced by server, and Sakai gets the best score in this case.

In the Fig. 10 we can observer the number of cache Reading in the server. In this case we see the Moddle platform performed more readings than Sakai, but these readings provide few load on the server. In Sakai we have a maximum in 6E+16 and with Moddle this maximum is around 5E+16.

In this case (see Fig. 11) Moddle has large variations. With this same platform when we have more users the number of readings in cache increases. In the case of Sakai we see that when we have several users also increases but this increase is very small.

When one or several users access to the server to download a file, the number of readings in cache is very variable (see Fig. 12). When we have a user we see that Moddle starts before to make readings in cache that Sakai and moreover, these are smaller in size. When the user number increases, the effect is very similar. In this case notes that Sakai needs to make a higher number of readings in cache that Moddle to serve the same content.

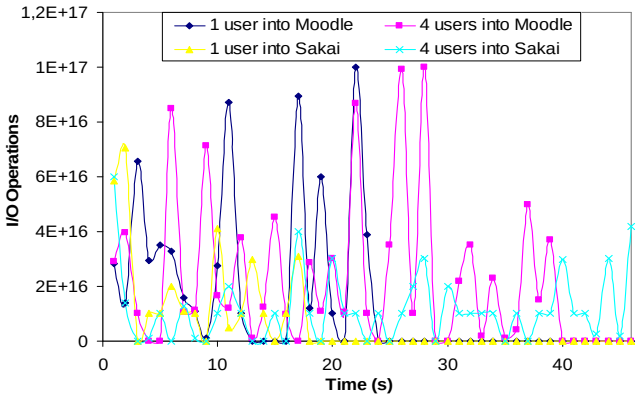

Figure 6. I/O operations due to user authentication and access

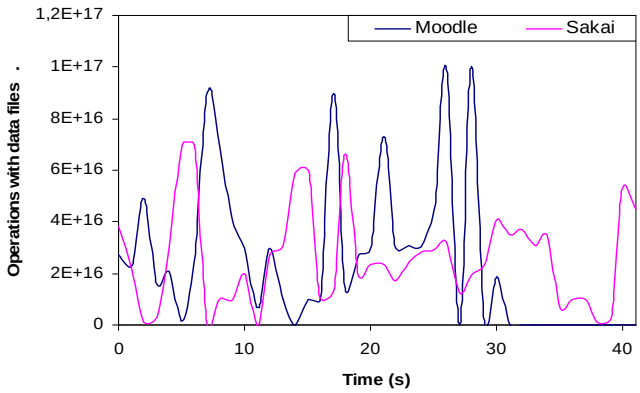

Figure 7. Operations with data files per second uploading a file to the server

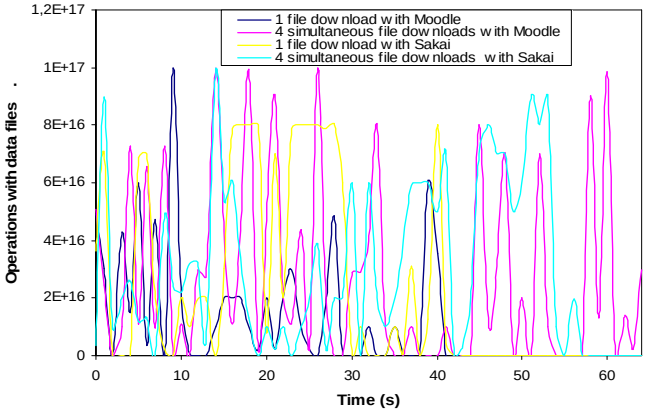

Figure 8. Operations with data files during file downloads

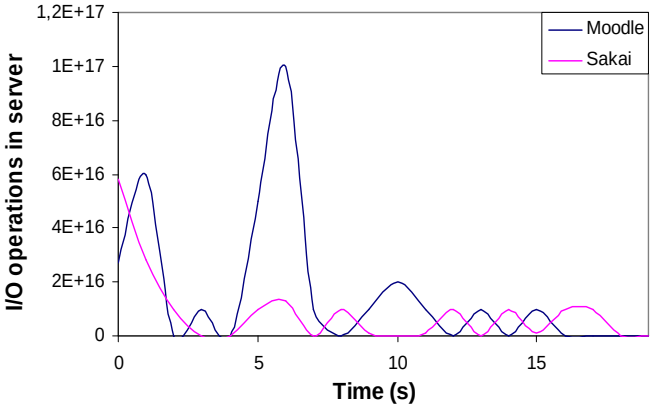

Figure 9. I/O operations in the server when a file is uploaded.

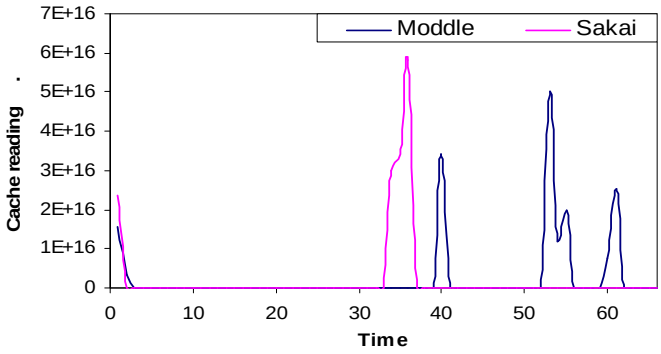

Figure 10. Cache reading when a file is uploaded.

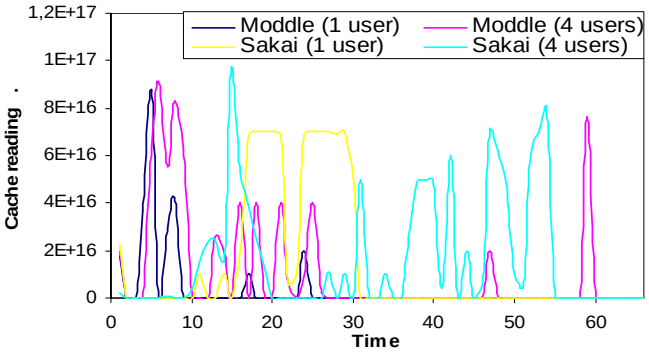

Figure 11. Cache reading when several users access.

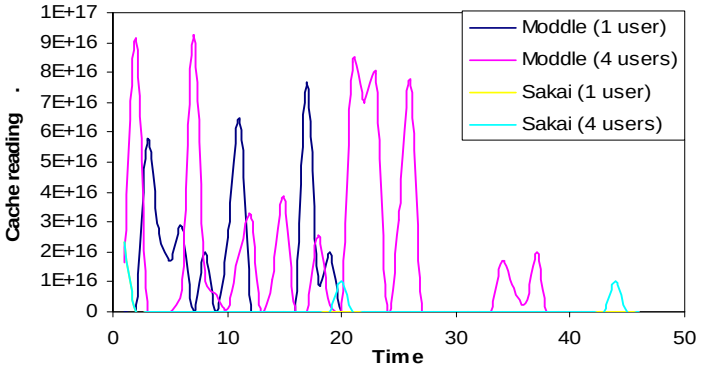

Fig. 12. Cache reading when several users download files.

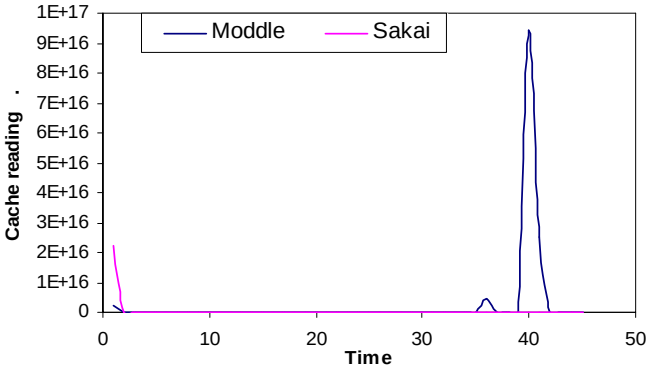

Fig. 13. Cache reading when the administrator makes an announcement.

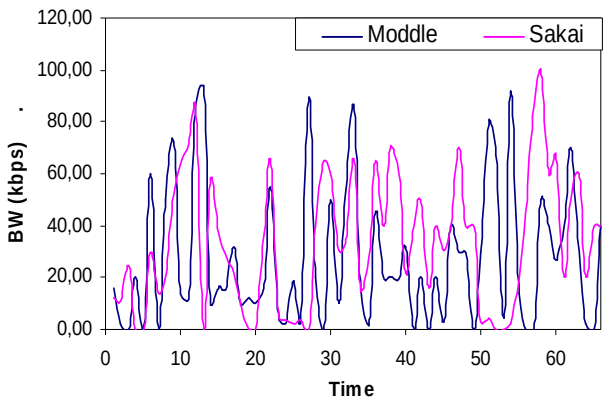

Figure 14. Bandwidth used when the administrator uploads a file.

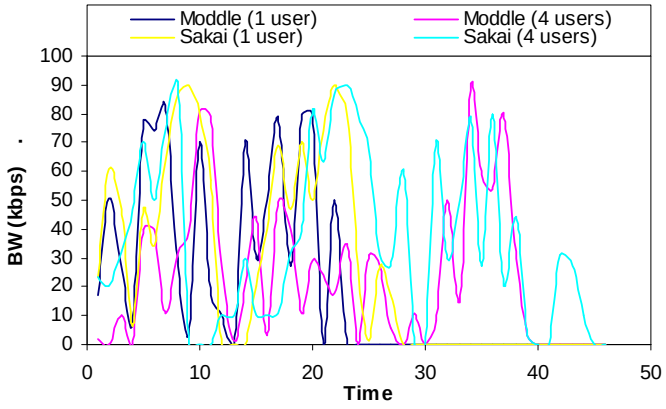

Figure 15. Bandwidth used when several users access to education platform.

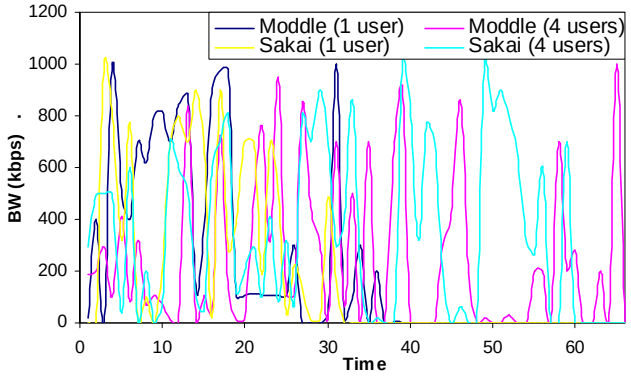

Figure 16. Bandwidth used when several users download files.

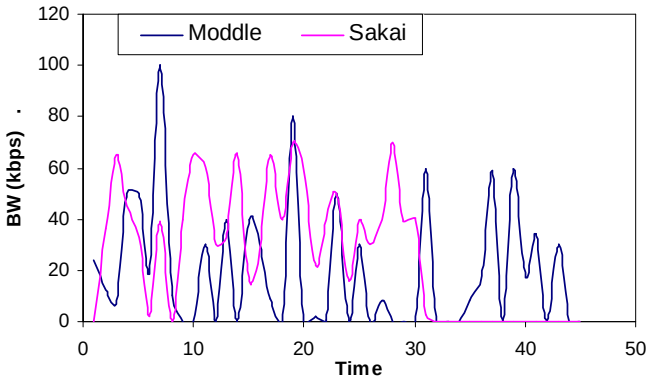

Figure 17. Bandwidth used when the administrator makes an announcement.

In the Fig. 13, we have the readings in server cache when the administrator makes an announcement for the community. In this figure we can see that Sakai requires a greater number of readings in cache at the beginning. After that it does not perform more similar tasks. In contrast to Moddle performed few readings in cache at the beginning but when the announcement is published requires more readings.

In the Figure 14, we have the bandwidth necessary to upload a document to the server. In both platforms we see that the bandwidth is very variable along the time. If we analyze the figure in depth, Sakai will need a little more bandwidth to upload the same file that Moddle, this must be Sakai is based on Java.

If we analyze the bandwidth used when one or several users access to the server, we see that this bandwidth is very small (see Fig. 15). The server uses more bandwidth when we have several users accessing the server (a maximum of 90 kbps). The same as occurred with the readings in cache, you need more time for access to all customers

In the Fig. 16, we observe the bandwidth used when one or several users are downloading a file. In this case the bandwidth is very variable for all the cases. When we have one or several customers the platform more quickly to download the file is Sakai. But this platform sends in big gusts so it can bring problems to the end user according to his Internet connection.

The fig. 17 shows the bandwidth used by the server when we create an announcement. With this graph we see that the necessary bandwidth is not very high (100 kbps with Moddle and 75 kbps with Sakai as maximum). The platform faster is Sakai. As we saw in the previous figures, Sakai requires less time, but during that time it uses higher bandwidth.

8 Conclusions

Virtual learning environments are the future in the academic field, not only at high education, but also at secondary education, where they are being introduced.

They are used by all universities around the world and every day new applications are added to the virtual learning platforms. The objective is to improve the efficiency and the interaction between the students.

This paper has shown the popularity of the most used virtual learning environments and explains their main features.

In spite of its large utilization and expansion, the study shows that many lecturers don't have too much knowledge about this type of applications. Because of that, many available tools aren't used by them. They only use indispensable applications like upload notes or send an e-mail.

Our study about virtual learning platforms in the Spanish universities shows that the most used platform is Moodle.

On the other hand, the virtual learning environment that gets better (in average) results in the tests performed has been Moodle.

These systems are the basic tools to transform and update present educational system. But they should continue improving existing applications and creating new of them.

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