

FLOSS in Technology-Enhanced Learning

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Abstract. This paper presents a comparative analysis of Free/Libre Open Source Software (FLOSS) Learning Management System (LMS). Following a selection process we analyze the functionalities and characteristics of 8 tools commonly used in formal and informal education. More specifically we focus on the availability of different tools concerning communication and assistance, such as, forum, email, calendar, portfolios, etc. Our analysis showed that despite their similarities, the appropriateness of different FLOSS LMSs can be greatly affected by the specific needs of students, instructors and institutions.

Keywords: FLOSS · Learning management system · e-Learning

1 Introduction

Adopting online education can be regarded as a natural transition for the 21st century institutions. It is perceived as an innovation that has considerable potential for enhancing teaching and learning, promoting lifelong learning and reaching out to non-traditional learners [1].

With the current international crisis, cuts in funding for education have a very high adverse impact [2]. The need to reduce costs, maintaining educational quality, gathered with the fact that institutions rely on the Internet to perform many of their activities, makes it necessary to introduce new approaches into education that will enable governments to continue promoting high-level education. Free/Libre Open Source Software (FLOSS) [32] is regarded as the solution that emerges from these needs.

FLOSS is a result of a development process that respects freedom and takes place within a community of practice. It allows institutions to be more independent from the pricing and licensing policies of software companies, and empowers users with independency to run, copy, distribute, study, change, and improve it according to their needs.

Hence, institutions' need to reduce costs, provide students access to new ways of learning, and follow up with the advance in technology, suggest that applying the FLOSS paradigm to education may be an advantage to explore. Not only the FLOSS paradigm can be modeled according to the needs of specific Higher Education

Institutions (HEIs), but also adapted to other educational contexts such as informal learning and long life learning.

The research addressed by this paper is how to assess LMS projects based on experiences of their use in higher education. Addressing such a problem, we analyze a set of FLOSS LMS and their social and economic impact. The main contribution of the paper is to provide an assessment framework for analyzing LMS and some assessment results that can assist teachers and HEI decision makers in the selection of the suitable LMS.

The rest of the paper is structured as follows. Section 2 presents the background of our study, Sect. 3 the proposed methodology. Results and their analysis are detailed in Sect. 4. Finally, Sect. 5 concludes and lists some topics for future work.

2 Background

The use of Information and Communications Technology (ICT) in educational contexts often requires the use of terminology whose meaning may depend on the context in which they are used. The following definitions are adopted in this paper.

- Learning management systems (LMS) are software systems designed to support student learning. They contain a number of presentation, assessment, communication, and management tools. Examples include Moodle, Sakai and OpenSE.
- e-Learning is the use of Information and Communication Technologies (ICT) to assist the teaching/learning process [3].
- Technology-Enhanced Learning (TEL) is any online facility or system that directly supports learning and teaching. This may include a formal virtual learning environment (VLE), an institutional intranet with learning and teaching components, a system that has been developed in house, or a particular suite of specific individual tools [4].
- Technology Enhanced Learning Environment (TELE) is a learning environment that uses technology to enhance and enrich the learning process [5].
- Computer-supported collaborative learning (CSCL) is a pedagogical approach where learning takes place via social interaction using a computer or through Internet. This kind of learning is characterized by sharing and construction of knowledge among participants, using technology as their primary mean of communication or as a common resource [28].
- Instructional Methods [6] are methods used in teaching which include:
 - Explaining, by oral explanations on the subject to be learned;
 - Demonstrating [29], through examples or experiments;
 - Collaborating, allowing students to actively participate in the learning process by talking with each other and listening to others points of view;
 - Learning by Teaching, by making students to assume the role of teacher and teach their peers.

Technological tools in education have a considerable impact and can be regarded as facilitators during the teaching and learning process [30]. They promote

collaboration between students as well as collaboration between students and teachers. In Educational Studies this is designated as collaborative learning [31].

e-Learning 2.0 led to the concept of social learning. Social learning refers to the perspective that states that people learn within a social context and it is facilitated by concepts such as modeling and observational learning [26]. From an e-Learning 2.0 point of view, conventional e-Learning systems were based on instructional packets, which were delivered to students using assignments. A teacher was up to the task to evaluate these assignments [7]. Therefore, e-Learning 2.0 led to the concept of *social learning* through the use of social software tools such as blogs, wikis, forums, and chats, promoting learning at a wider scale than individuals or learning groups, up to a societal scale, through social interaction between peers [8].

FLOSS is software that is both Free and Open, and is liberally licensed to grant users the right to use, copy, study, change, and improve its design through the availability of its source code. This approach has gained both momentum and acceptance. As the potential benefits increased, the recognition by individuals and corporations also increased [9].

Depending on the level of political correctness and the intention of the author, the terms Free Software (FS), Open Source Software (OSS), Free and Open Source Software (FOSS) or Free/Libre Open Source Software (FLOSS) are more or less, used interchangeably in the literature. As Richard Stallman puts it, “Open Source is a development methodology, free software is a social movement” [10].

We will use the acronym FLOSS throughout this paper.

As far as development is concerned, FLOSS is developed inside communities in the precise sense of “collectives of individuals that cohere around a shared spirit” [11]. Most of the existing open source software is developed in such communities. Its code is typically created as a collaborative effort in which programmers improve code, test, document, discuss and share changes.

Although FLOSS products are perceived as being of high quality [12], they present pros and cons. On one hand, FLOSS products are popular, because they are free of costs, developed by volunteers with different backgrounds that bring positive contributions to the project, and, hopefully, are always updated and with constantly new features. On the other hand, because of the different backgrounds, the releases of new features can be delayed; volunteers can stop their contribution, killing, in this way, the project [13].

3 Method

3.1 Pre-selection

We have initially searched for educational projects in the SourceForge [14] repository. Then, we have refined our selection by searching for the keywords Learning Management System (LMS). The initial list had over 30 LMS projects and we narrowed it down to 11 by selecting only those open source Learning Management System projects that have downloads on a weekly basis. We argue that the number of downloads per week is a parameter that should be considered as a mere indicator of the LMS

acceptability. Moreover, we understand this as an indicator of the number of users that are aware of the considered LMS.

After the pre-selection of the LMSs, we gathered more information using UrlSpy [15], a database containing information on hundreds of thousands of websites.

As shown in Table 1, for each project we considered the following data:

- World Wide Rank, i.e. the position of the website in the world wide rank of most visited website;
- Total No of Years, i.e. the number of years the tool as been available;
- External Links, means the number of websites that refer the project website;
- Number of Pages visited by users within the tool website.
- Estimated Daily Users, i.e. the estimated number of users of the website tool;
- Downloads per week from SourceForge,

From the selected LMSs, Moodle is number one in the World Wide Rank, with 37300 External Links. The number of External Links can be regarded as a measure to analyze the impact of the project worldwide. It is interesting to notice that almost all LMSs have been available for more than 10 years. The most recent ones are Dokeos and Open Elms. Since data from e-Learning Applications Suite, Docebo reborn and Brillhaspati were not available, we decided to narrow the sample to the 8 LMSs: Moodle, ILIAS, Claroline, Open Elms, ATutor, Dokeos, EClass.Net and Sakai.

By narrowing the sample we consider a relationship between the data presented in Table 1 and the social impact of these projects. For example, the Estimated Daily Users is considerably higher for Moodle. Data in Table 1 prove the popularity of Moodle. However, drilling down in the analysis, it is clear that Dokeos, with 7 years

Table 1. FLOSS LMS projects data using SourceForge and UrlSpy.

LMS	World wide rank	Total no of years	External links	Number of pages	Estimated daily users	Downloads per week from SourceForge
Moodle	5717	<11	37300	28650	71370	16796
Dokeos	68947	7	3221	3345	6388	53
Claroline	110 846	<10	2829	821	4165	597
ATutor	154563	>11	2426	345	2948	224
Sakai	206 726	>11	2127	1386	2551	3
ILIAS	292 306	<11	813	356	1240	428
Open Elms	989 640	4	92	35	398	104
EClass.Net	14 019 198	<9	36	6	16	25
e-Learning applications suite	n/a	>5	n/a	n/a	n/a	17
Docebo reborn	n/a	<1	n/a	n/a	n/a	28
Brillhaspati	n/a	>7	n/a	n/a	n/a	19

of existence, is gaining popularity very fast, considering that the closest player, Claroline, has been available for almost 10 years.

Next, the selected LMSs are briefly described.

Moodle – is an LMS for producing Internet-based course websites. It has been designed to support modern pedagogies based on social constructionist theory, and includes activity modules such as forums, resources, journals, quizzes and others. Also, Moodle allows developers to extend it by creating plug-ins for new functionalities. Moodle is written in PHP [16].

ILIAS – is an LMS based on the concepts of Personal Desktop and repository. While the Repository contains all content, such as courses and other material structured in categories, the Personal Desktop is an individual workspace for each learner, author, tutor and administrator. A Personal Desktop contains the selected items from the Repository as well as certain tools like mail, tag-in, calendar and also a portfolio and personal blogs. ILIAS is written in PHP [17].

Claroline – specific for educational purposes, this system is based on some specific principles of Moodle. It supports SCORM content as well as a built-in wiki and other online content tools. It is developed on PHP/MySQL and allows teachers or educational institutions to create and administer courses through the Web. It provides group management, forums, document repositories and calendar [20].

Open Elms – although an LMS for training and business it is, in fact, known as the first open source Learning Management System aimed at business. It is also known because of its 3D virtual room [19]. Open Elms is written in ASP and Java.

ATutor – is a platform to develop and deliver online courses. It is possible to install it within minutes and supports easy distribution of web-based instructional content for online courses. It is written in PHP [18].

Dokeos – is an e-Learning and course management web application, translated into 34 languages and used by multinational companies, government agencies and universities. It is written in PHP, using MySQL as database backend [21].

EClass.Net – is a platform for users to build a set of easy to use, cross-platform software tools for developing e-books and learning modules. It is written in Python. [22].

Sakai – is a free educational software platform and is used for teaching, research and collaboration. Sakai is written in Java [23].

3.2 Assessment Criteria

To assess the 8 pre-selected LMS tools we propose an assessment framework, as the one depicted in Fig. 1.

The main concepts of our framework are: Selected Tools (as explained in Sect. 2), Functionality Criteria, and Impact Criteria.

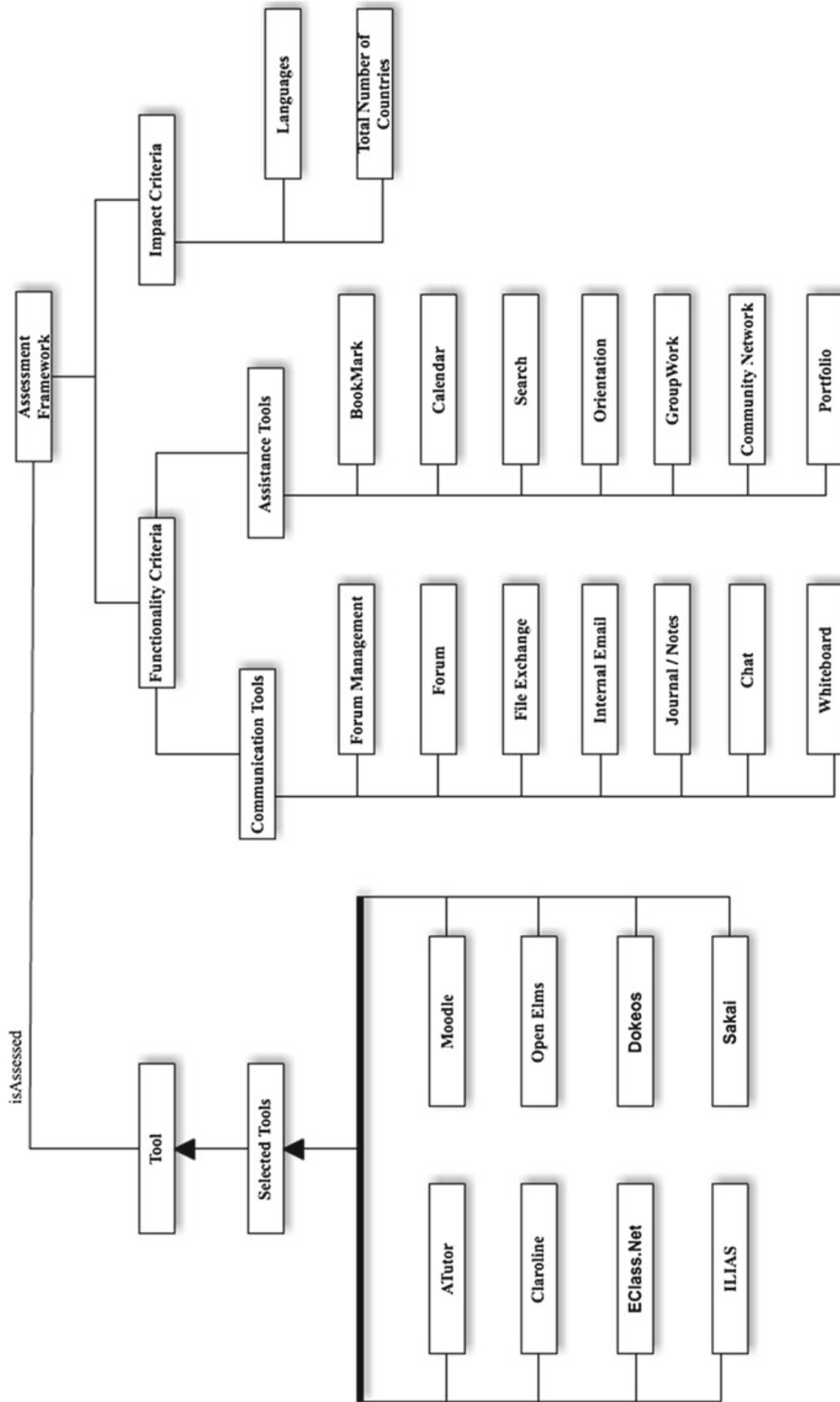


Fig. 1. Assessment framework.

Functionality Criteria correspond to features of the software. They are categorized in two main areas [24]: communication tools [27] and assistance tools [25]. Functionality Criteria allow to determine if Instructional Methods used in formal education are available or not in e-Learning tools. In Sect. 2, we have introduced the following Instructional Methods: Explaining, Demonstrating, Collaborating and Learning by Teaching [6]. Within the communication tools, tools that help users to communicate, we considered the following requisites: Forum, Forum Management, File transfer, Email, Online journals/Notes, Chat and Whiteboard. For the Assistance tools, tools that assist teachers and students during the performance of their tasks, we consider the following requisites: Bookmarks, Calendar, Search of content, Orientation, Group Work, Community Networking and Portfolios. The description of each category is shown in Table 2. The Instructional Methods are available in the communication tools. For example, Explanation and Demonstration methods are available in almost all LMSs through Whiteboard, Group Work and Orientation. The Collaborative Method is available in Forum and Group Work. The learning by teaching method, where the students assume the role of teacher, can be found on Community Network.

Table 2. Description of the LMS features.

Communication tools	
Forum	Students can submit posts in a discussion forum. They can also enable and/or disable posts
Forum management	Within the forum management, teachers or instructors can create discussion forums, moderate discussions and access to statistical information
File exchange	Files can be uploaded and download by students and teachers or instructors
Email	Teachers or Instructors can email an entire class by using a single email alias
Online journal/notes	Enables students to make notes in a personal or private journal. Students can share personal journal entries with their instructor or other students but cannot share private journal entries
Chat	Allows synchronous messaging discussion groups
Whiteboard	Tool used by instructors and learners in synchronous modes (virtual classroom)
Assistance tools	
Bookmarks	Accessed through a menu, bookmarks help organize contents
Calendar	Allows students and teachers (or instructors) to create events in the online course calendar. It also supports announcements
Content search	Feature that allows students and teachers (or instructors) to search for contents
Orientation	Online help for students and teachers (or instructors)
Group work	It is possible to create groups for discussions, assignments, or any other activity
Community network	Students can create online clubs, interest groups, and study groups at the system level
Portfolios	Feature that allows students to collect their work

Hence, the large range of available Instructional Methods make all considered LMSs effective tools to support both formal and informal education.

With respect to Impact Criteria, we determined the impact of each project by analyzing data presented in Table 1, as well as the Number of Languages in which they are available, and the Total Number of Countries in which they are established. We consider Impact Criteria as the most relevant for the analysis of the concept of e-Learning 2.0 and the concept of *social learning* since, with these parameters, we can determine the range of a certain tool.

4 Results and Analysis

Functionality Criteria cover two main areas: (a) Communication Tools, and (b) Assistance Tools. We analyze the existence or absence of Instructional Methods.

For the Impact Criteria analysis, a broader analysis aims at presenting the impact of each LMS tool. Hence, we conclude our analysis by presenting recommendations for the choice and usage of LMS according to social and economic viewpoints.

As shown in Table 3, with the exception of Open Elms and EClass.Net, the tools fulfill all requisites for communication tools introduced in Sect. 3.2. EClass.Net does not provide clear information about the communication tools since the LMS from the project has been discontinued and is now an application to create e-books. Note that only some of the Instructional Methods are available in the communication tools. For example, Explanation and Demonstration methods are available in almost all LMSs through Whiteboard, and the Collaborative Method is available in Forum.

As shown in Table 4, Explaining and Demonstrating are available in almost all LMSs through Group Work and Orientation, which allows oral explanations and examples. The collaborative method is present, for example, in Group Work. Finally, the learning by teaching method, where the students assume the role of teacher, can be found on Community Network. Hence, the large range of available Instructional Methods make all considered LMSs effective tools to support both formal and informal education.

Table 3. LMS tools analysis according to the communication tools.

Features	Communication tools							
	Moodle	ILIAS	Claroline	Open Elms	ATutor	Dokeos	EClass.Net	Sakai
Forum	X	X	X	n/a	X	X	n/a	X
Forum management	X	X	X	n/a	X	X	n/a	X
File transfer	X	X	X	X	X	X	n/a	X
Online journals/notes	X	X	X	X	X	X	n/a	X
Share online journal	X	X	X	X	X	X	n/a	X
Chat	X	X	X	X	X	X	n/a	X
Whiteboard	X	X	X	n/a	X	X	n/a	X

Table 4. LMS tools analysis according to the assistance tools.

Features	Assistance tools							
	Moodle	ILIAS	Claroline	Open Elms	ATutor	Dokeos	EClass.Net	Sakai
Bookmarks	n/a	X	X	X	X	X	X	X
Calendar	X	X	X	X	X	X	n/a	X
Search for content	X	X	X	X	X	X	n/a	X
Orientation	X	X	n/a	X	X	n/a	n/a	X
Group work	X	X	X	X	X	X	n/a	X
Community network	X	X	n/a	X	X	X	n/a	X
Portfolios	n/a	n/a	n/a	X	X	X	n/a	X

Table 5. Impact criteria data.

Features	Impact criteria							
	Moodle	ILIAS	Claroline	Open Elms	ATutor	Dokeos	EClass.Net	Sakai
Languages	78	26	35	1	20	20	n/a	12
Number of countries	216	53	71	156	58	60	n/a	17

For analyzing the Impact criteria data was extracted from each LMS website and UrlSpy.

Table 5 shows, for each LMS, the number of languages in which it has been translated and the number of countries in which it is used. Moodle is in the first position with respect to both these parameters. Therefore, data presented in Tables 1 and 5, show that Moodle is the LMS with higher impact, and, thence, the number one open source LMS. However, this does not mean that others LMSs should not be taken into consideration.

Working with Table 1, we start grouping tools according to the proximity on the Work Wide Rank, the number of External Links and the number of Estimated Daily Users. Then we compared Dokeos with Claroline, ATutor with Sakai, and ILIAS with Open Elms.

Dokeos vs Claroline – These two platforms have the same communication tools, but Claroline lacks some of the features in assistance tools (Orientation, Community Network and Portfolios). Although Claroline is available in 35 languages (20 for Dokeos), and is used in 71 countries (Dokeos is used in 60), Dokeos is better classified in the World Wide Rank (Table 1). According to the number of External Links, Dokeos has more external references to its homepage than Claroline, although it is more recent.

ATutor vs Sakai – These two platforms have been available for over 11 years and have the same functionality features. From Table 5 we can observe that ATutor is available in more languages and present in more countries. Also, based on Table 1 we can observe that ATutor is better classified in the World Wide Rank than Sakai. The

number of External Links is very similar for these two platforms, having ATutor just a slight advantage. The number of Estimated Daily Users is also very similar.

ILIAS vs Open Elms – Although Open Elms is available in more countries than ILIAS, it is only available in English language. This makes this tool less interesting than ILIAS. Open Elms is in the 989640th position on the World Wide Rank. Being ILIAS on the 206726th position means that ILIAS is better positioned than Open Elms. Moreover, the difference between the number of External Links is considerable for these two platforms. ILIAS has 813 external Links compared to only 92 for Open Elms, as a clear indicator of the impact of these platforms.

Although these LMSs are free and open source, this does not mean absence of any sort of exploration cost. In particular, the support service of ATutor and Open Elms is not free of charge. Hence, the tools we suggest are: Moodle, Dokeos, Claroline, Sakai and ILIAS. The decision on which tool to choose relies on requirements such as: if a Portfolio is needed, then Moodle, ILIAS and Claroline are not suitable options. If Orientation is required, then Claroline and Dokeos are not an option. If, for example, Bookmarks are required, Moodle is not an option. By analyzing Tables 3 and 4, we observe that Sakai is a more complete tool, and therefore easier to adopt than Moodle, even if the latter is available in several languages.

It is interesting to analyze that according to the size of the institution and the number of students, some platforms become more suitable than others. For example, as far as the Calendar is concerned, it is an effective way to announce new events and schedule activities within the courses. The Calendar not only allows students to keep track of all activities of the course, but also promotes awareness of new activities. With an increase of activities, announcements and documents the search for data may be difficult. The Content search allows a faster way to track it.

Portfolios are an effective way to gather information about students work. However, they may not be relevant for an institution with thousands of students' to keep all students' records. When it comes to smaller institutions, the Portfolio can actually be a good feature since it can give the teacher more information on the tasks each student performs. Among all relevant features, Community Networks can be regarded as a supporting tool for collaborative learning. In a Community Network, students can create online clubs, groups of interest and study groups. This feature along with, for example, Group Work, is very relevant when it comes to the social learning. It allows a peer-to-peer learning, were all students gather with the same purpose and the same interest.

5 Conclusion and Future Work

In this paper, we present an explorative data analysis of several FLOSS LMSs, in order to define some guidelines to help educational institutions to make a choice between them. We showed that different LMSs address different needs. We analyzed each tools independently, and in comparison with others. The analysis was performed using two sets of Criteria: Functionality and Impact. For the Functionality Criteria, we were able to determine the features available in each tool, assessing, in this sense, their relative characteristics. For the Impact Criteria, we analyzed different and relevant

statistics of each tool, showing the relevance and importance of the LMS. We started the analysis with the World Wide Rank, to obtain an overall view of the importance of the tool. Then, we analyzed the number of External Links, meaning how many websites refer to each tool. We also analyzed the number of countries and the number of languages in which each tool is available. Also, and due to our interest on the FLOSS paradigm, we examined whether the tools are free of costs. We were able to determine that, although some tools are free of costs and developed under the FLOSS paradigm, their support is not free.

For future work, we intend to pursue the analysis of the 8 selected tools. In particular, a usability study from both the teachers' and students' perspective seems most relevant now. We also intend to conduct further analysis from an educational point of view concerning the support of instructional methods, such as individual and collaborative learning using survey techniques.

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