Evaluating On-line Learning Platforms: a Case Study

F. Colace, M. De Santo, Member, IEEE, M. Vento, Member, IEEE
Dipartimento di Ingegneria dell'Informazione e Ing. Elettrica (DIIIE)
Università degli Studi di Salerno
Via Ponte don Melillo, 1
84084 Fisciano (SA), Italy
{fcolace, desanto, mvento}@unisa.it

Abstract

Our "information-oriented" society shows an increasing exigency of life-long learning. In such framework, on-line Learning is becoming an important tool to allow the flexibility and quality requested by such a kind of learning process. In the recent past, a great number of on-line platforms have been introduced on the market showing different characteristics and services. A series of features should be taken into account when one evaluates e-learning platforms, starting from the function and usability of the overall learning system in the context of the human, social and cultural organization within which it is to be used. Obviously, the analysis of the features of a system is not sufficient: it is also important to understand how they are integrated to facilitate learning and training and what principles are applied to guide the way the system is used. To evaluate them both pedagogical and technological aspects must be carefully evaluated. This paper proposes a model for describing and characterizing on-line learning platform component. The model is then used to evaluate the most known existing commercial platforms.

1. Introduction

The whole world is undergoing a change that maybe is the most important one in the last thirty years, and, through the spreading of new information technologies, is deeply modifying relations among countries, markets, people and culture. The technological revolution has clearly promoted a globalization process (the Internet represents the global village better than any other tool does) and information exchange. Nowadays, information can be considered as an economical value whose significance is closely associated with the knowledge that it offers people benefiting from it. Constantly up-dated knowledge is a fundamental and decisive aspect of professions related to the New Economy. New society's dynamism does not well adapt itself to past training

models developed in more static or slowly changeable contexts [1]. The pressing need for new knowledge and competences has really shattered this boundary and professional people are nowadays obliged to continually qualify themselves and to be always willing to acquire new knowledge.

In the light of this, a need for new didactic models has arisen. These models are based on the idea of long-life learning. With respect to this question, both pedagogical and technological aspects must be carefully evaluated. In the first case, it is necessary to develop new training models clearly defining how to organize new training paths and the didactic contents associated with them, as well as how to provide these contents in relation to the user who benefits from them. As for the technological aspect, new tools for distributing knowledge must be created, tools able to reproduce as efficiently as possible pedagogical training models. The goal of this paper is to present the results of a research aimed to characterize the technological and pedagogical aspects of distance learning for evaluating on-line learning platforms, which are the basis for providing training contents over the web. The paper also reports the application of the proposed evaluation model to a significant sample of existing commercial platforms.

2. On-line Learning Environments

The Internet offers effective tools for exchanging information that can be used in different ways for on-line learning. Chat (textual message exchange) and e-mail are currently the most widespread ones, since they have first arisen in the Internet world. However, new technologies and the use of wider transmitting bands allow to utilize audio/video communication tools in real time as well as to share multimedia contents. At first, on-line learning platforms had to integrate such services. NetMeeting application developed by Microsoft is a useful example to understand how a distance learning tool was structured. NetMeeting offers such services as on-line textual chat, videoconferencing, audio chat, application sharing and whiteboards. At least until the first half of the 90s, this

was the predominant way of organizing distance education platforms. Once technological problems related to the delivery and implementation of such services was resolved, industries have began to improve platforms by introducing modules and services able to manage pedagogical aspects (associated with the training process) [2] as well as content updating and availability. In our opinion the most part of contemporary e-learning platform can be viewed as organized into three fundamental macro components: a Learning Management System (LMS), a Learning Content Management System (LCMS) and a Set of Tools for distributing training contents and for providing interaction.
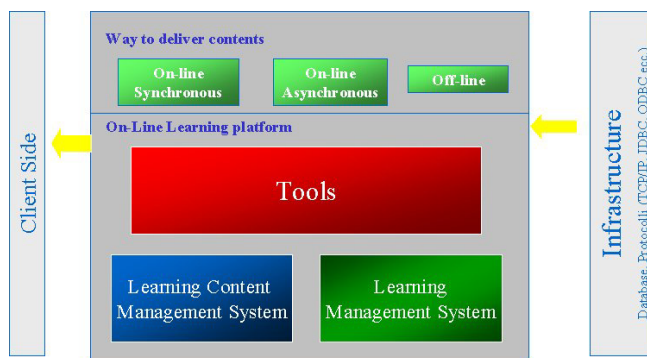
Figure 1: Typical architecture of an e-Learning platform

The LMS integrates all the aspects for managing on-line teaching activities. The LCMS offers services that allow managing contents while paying particular attention to their creation, importation and exportation. The Set of Tools represents all the services that manage teaching processes and interactions among users.
In the following, after describing in detail the characteristics of the LCMS, LMS, and Set of Tools, technological and pedagogical requisites for a distance learning application will be defined, in order to outline an evaluation model.

2.1 Learning Content Management System (LCMS)

A Learning Content Management System includes all the functions enabling creation, description, importation or exportation of contents as well as their reuse and sharing. Contents are generally organized into independent containers, called *learning objects*, able to satisfy one or more didactic goals. An advanced LCMS must be able to store interactions between the user and each learning object, aiming at gathering detailed information about their utilization and efficacy [3]. When one talks about on-line learning, it is natural to think of interactive media-based contents. Actually, this is only a part of the widespread contents. The contents available before the spreading of on-line learning were mainly documents, and most of them have been proposed as didactic material in HTML format for on-line courses. In addition, interactive media have been sometimes introduced, such as audio, video or training resources created by using other multimedia tools (for example, Flash). A good LCMS should accurately choose the contents to be offered to the student during the lessons as well as the way in which they must be provided. The importance of LCMS is related to the growing distance learning request that is determining a significant increase in content production. The current effort is to avoid a useless duplication of contents by realizing learning objects consonant to given standards in order to reuse them in different contexts and platforms. All the contents must be appropriately stored in special repositories and be easily accessible and updatable. In fact, a LCMS must be designed so as to enable a constant updating of its contents, allowing this process (if possible) to semi-automatically take place. It is important to point out that, from our point of view, contents are not considered as objects external to the platform but as integral parts of it. This is possible thanks to the services that constitute the learning content management system. The trend towards a growing of training resources, though necessary to better characterize the training process, does not allow the teacher an easy consultation and use of these ones. At the same time, such an important number of resources can disorientate students that may run the risk of not choosing, during the auto-training phase, the contents more suitable to them. A solution to this problem is given by a more detailed description for each single content so as to avoid ambiguity or duplication among them. In particular, some information will support the content so as to better identify the domain in which resources are included and to draw LCMS and teacher's attention to the most peculiar characteristics of the training content. In literature, this descriptive process is known as metadatation [4]. At present, the scientific community and industries engaged in this field are trying to define standard metadata rules, so as to encourage understanding of the real semantic content of the various training resources. From this point of view, such organizations as LTSC sponsored by IEEE or IMS Global Learning Consortium [5][6] are trying to create standardization rules and processes able to describe training resources as well as the user and training paths. Therefore, the aim is not only to facilitate and automate research and training resource acquisition over the web, but also to find the contents that better satisfy the student training needs [7].

2.2 Learning Management System (LMS)

The Learning Management System (LMS) embraces all the services for managing on-line teaching activities. In particular, it aims to offer management functionality to training platform users: system administrators, teachers and students. From students' point of view, a LMS must offer services able to evaluate and report the acquired skills storing the training path followed by them. The System administrator should have the possibility of drawing up statistics on the use of platform services in order to better organize on-line learning service delivery. A LMS should give the teacher the possibility of verifying the right formulation of the various lessons and suggesting changes (in case it is semi-automatically inferred from student tracking) in the learning path. Therefore, the functionalities of a LMS integrated within a distance learning platform can be synthesized as follows:

- Student management
- Course management
- Student skill assessment
- Student activity monitoring and tracking
- Activity reporting.

A student management system integrated within a LMS must manage a database containing standardized descriptions of student data so as to better identify the user and his/her characteristics. This type of description is generally based on the XML meta-language (Extensible Markup Language), an element that guarantees data portability. When we talk about portability, we refer to the possibility of accessing a resource, in this case, the students' descriptions, independently of the computer type and operating system. This characteristic is necessary for an e-learning platform that aims to be compatible with a high number of hardware platforms, operating systems and standard applications. Standardized descriptions of users can be then used within the platform to store personal data, training profiles and the most significant events characterizing their training path. A LMS must implement a functionality that adds a significant value to the distance learning process. This functionality is that enabling the student to consult, at any time, results he/she has reached and, consequently, to monitor his/her preparation level. This possibility allows the student to understand his/her own gaps and, possibly, to identify the training contents more suitable to his formative requirements [8]. As for course management, an LMS can generally manage self-paced, asynchronous instructor-led and synchronous instructor-led courses. Self-paced courses are usually asynchronous, in hypertextual format, and give much freedom to the student who accesses a course index. The LMS system manages these courses starting from their creation. Asynchronous courses are run by an instructor, but they do not foresee interactive moments between students and instructor. Their design foresees delivery of strongly multimedia-oriented contents. Synchronous courses generally make use of collaborative learning, that is of all the tools that allow creating interactions in real time between students and instructor. The LMS must keep track of who is present at the courses. These functions are useful to students, who can know how they are using the course, and teachers, who can control student participation in the courses, as well as to administrators that evaluate the use of on-line courses in order to determine their efficiency and convenience.

2.3 Tools for delivering and accessing contents

On-line training efficiency is directly related to the tools made available by the delivery platform as well as to their usage easiness. The services should satisfy teacher and student needs and it is therefore necessary that the same kinds of services are different in accordance with the user. In particular, teachers should be provided with tools enabling them to manage teaching processes for single individuals or groups, as well as all the interactions, including asynchronous discussions or live events. In addition, it is important to provide the teacher with updated reports on learner or learner groups' progresses so as to better manage evaluation processes and facilitate activities. Besides, it is necessary to give students the possibility of synchronously and asynchronously communicating with both the teacher and other students.

We will shortly analyze some of the most popular services that characterize on-line training platforms from a collaborative point of view, and that they tend to integrate within themselves.

The Virtual Classroom Service is a service designed for distributing courses in a synchronous mode, and also for supporting on-line live teaching. This type of service aims to reproduce the mechanisms present in a classroom during a traditional training session and is considered as a kind of container in which all the services able to recreate a virtual classroom atmosphere will be included. The use of a virtual classroom is obviously foreseen during "live" lessons in order to better manage synchronous interactions.

The synchronous communication systems are based on audio and video conferencing technologies. The

possibility of transmitting network videoconferencing has been implemented through the introduction of compressing movie techniques that allow reducing the use of bandwidth during the transmission in comparison with the uncompressed movies, intelligibility being equal. However, it is true that compressed video stream representations do not generally guarantee high definition movie reproductions. The latter can be anyway obtained by using high capability transmitting channels (a satellite channel, for example), whose utilization can be more expensive.

Audio/video conferencing tools allow the display and dialogue in real-time among the various members located in remote areas. The interface generally presents a window in which the video captured by a videocamera is displayed.

Another service enabling synchronous communication within e-learning platforms is provided by chat. This service allows participants to send textual messages to the other students or the teacher in a public mode (all the participants see all the things) or a private one (only who is directly involved receives the communication). Chat service surely increases collaboration within the environment in which it is used, but the teacher or tutor must continuously monitor its utilization, since it could lead to a lack of attention and confusion within the virtual classroom. In addition to a textual chat, the most recent platforms tend to implement a vocal one by using VoIP mechanisms.

From an historical point of view, the whiteboard has been one of the first services made available by an on-line learning platform. This service makes it available and shareable to teachers and learners a virtual space, usually called whiteboard. Both teachers and learners can work with it by virtue of control rights. This tool allows to write and draw on a shared space and to display PowerPoint presentations and images.

E-mail has been one of the first asynchronous communication tools used by e-learning environments. Thanks to this service, students can send messages to a specific addressee only by having his/her e-mail address. Some platforms can include, within their own infrastructures, functionalities for exchanging e-mail messages, but most of them allow the integration with tools developed just for this purpose, such as Outlook Express, Netscape Messenger, Eudora, etc.

3. Characterizing distance learning platforms

As previously discussed, an on-line learning platform can be characterized through an analysis that takes into account:

- the adopted methodologies;
- the level of the training path personalization;
- operative modalities and didactic interaction quality;
- learning assessment and student tracking methods;
- typology and quality of both didactic material and support system.

In order to meet the exigencies of distance training processes, support technologies should also have characteristics that make the training process functional and available. In particular, the student should be allowed to fully benefit from auto-learning, auto-motivation and auto-evaluation methods [9], and at the same time tutor and teachers should be provided with a direct and constant contact with the learners. So distance learning platforms must adopt a pedagogical approach based on constructivism a theory that is based on results of Piaget's research [10]. Constructivist learning is based on students' active participation in problem-solving and critical thinking regarding a learning activity which they find relevant and engaging. They are "constructing" their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs. So a constructivist e-learning platform is an environment where learners collaborate and support each other using a variety of tools and resources, as well as an environment where knowledge is constructed and learners assume a central role in the cognitive process. On-line learning platforms can implement easily a constructivist approach [11] because they can allow easily:

- encouragement and acceptance of student autonomy and initiative
- encouragement of students to engage in dialogue, both with the teacher and within the group
- continuous feedback

In other words, an on-line learning platform must be able to efficiently and effectively manage the single components of the process and their interactions.

A distance learning platform that has these characteristics must carry out four principal functions: communication, information sharing, information access and co-operation. These functionalities characterize both the pedagogical and technological approach. As for technical requisites, the best solution to be adopted in platform design should be based on the utilization of a multilayered, web-based architecture [12][13]. In particular an e-learning platform must be web-based, in this way the client can access the environment by simply

using a web browser, without compelling the user to install other software into his/her computer. This characteristic should be always taken into account by industries producing distance training environments. Thanks to it, students only need a basic knowledge in computer science enabling them to interact with a browser, which also avoids difficult installations of proprietary software. Another technical requisite to be considered is portability, that is, the possibility for a platform to rightly work independently of the computer and the operating system on which it runs. Obviously, the possibility of not installing proprietary software into the client machine increases system portability, since it guarantees that all clients can use the same services. A further requisite, as previously described, is the system compatibility with the most accredited descriptive standards of training resources and users, such as AICC [14] and IMS [5]. Compatibility with these standards is fundamental, since it allows to import and export contents and courses realised by different industries, and gives the platform the possibility of being equipped with a still little used tool: the Intelligent Tutoring System (ITS). An ITS is an application that can semi-automatically reach decisions after acquiring information by the LMS and LCMS. In other words, an ITS has the task of monitoring students' behaviour and advise them on the most suitable retrieval programs [15]. Besides, on the basis of the acquired data, it can advise the teacher on a different lesson organization and a different technology use. In fact, a course designer must have the possibility of making the several training process modules interactive, of adapting the training paths to the specific learner needs, and defining new training paths by using those already existing. Such operations are surely speeded up by adopting descriptive standards, even when an ITS is not used. Another aspect to be evaluated is related to the services integrated into the LMS and LCMS. As for management, services able to manage enrolments, training paths, and student tracking are really significant and add a new value. Platforms including such systems are surely ahead of others in services, as these tools will represent in the next future the core of an e-learning environment. In general, at present, indispensable management services are the following:

- services for including and updating user profile
- services for creating courses and cataloguing them
- services for creating tests described through a standard
- user tracking services
- services for managing reports on course frequency and use

- services for creating, organizing and managing own training contents or contents provided by other producers

The aspect related to the offered services is particularly interesting, because it characterizes the pedagogical approach. An analysis of the teaching tools made available by the various platforms is therefore necessary. These tools, as previously discussed, can be divided into two fundamental categories:

- asynchronous communication tools
- synchronous communication tools

Such tools as e-mail, discussion forum or newsgroup surely belong to the first category. Asynchronous services are really important for an e-learning platform, since they eliminate the space and time limits that can exist among the interlocutors.

Tools that belong to the second category are:

- textual or vocal chat
- whiteboard
- live video stream
- virtual classroom
- application and file sharing.

Real-time communication is used to carry out at a distance activities that are normally performed in face-to-face meetings. In this way, learners can interact with teachers creating an atmosphere more similar to that of a traditional classroom. The use of these new technologies will lead to a pedagogical approach based on group's interactions, where the teacher has the role of facilitating and organizing discussions. This approach debates traditional teaching methods (in which teachers are dominant and students are passive) and substitutes them for one based on active pedagogy.

On the basis of the previous considerations, we have grouped the parameters of interest into four macro fields:

- system requisites
- training resources and course management
- user management
- services offered to users

For each macro field, an evaluation grid has been designed.

4. Examined platforms and analysis methodology

In this chapter, we show the results of the comparative evaluation of a significant sample of existing commercial platforms selected to survey the state of art. The following platforms have been examined:

- IBM Lotus Learning Space [16]
- WebCT [17]
- Intralearn [18]

- LearnLinc by Mentergy [19]
- Atena by DiDael [20]
- BlackBoard [21]
- Centra - Cisco [22]
- Apriori by GapMultimedia [23]
- Click2Learn [24]
- Training Office by Novasys [25]
- TopClass by WBT Systems [26]
- Jets by Ottawa University [27]
- Docent [28]
- SwitchPort by Limu [29]
- Ecollege [30]

Evaluation was carried out by comparing the chosen platforms on the basis of the parameters introduced in the third paragraph. Table 1 shows an example of the used evaluation grids.

system requisites	Learning Space	WebCT	Intralearn	LearnLinc	Atena	BlackBoard	Centra	Apriori	Click2Learn	Training Office	TopClass	Jets	Docent	SwitchPort	Ecollege
Web Based platform															
Modular System															
Portable system															

	Supported Characteristic
	Partially Supported Characteristic
	Non-Supported Characteristic

Table 1.   Example of an evaluation grid.

4.1 Comparison

Some indicators have been designed in order to easily point out strong and weak points of the various solutions. The first indicator is referred to the services that a platform can make available. Taking into account our model, services necessary for on-line training to be efficient are the following:

- E-Mail
- Textual or vocal chat
- Whiteboard
- Discussion forum
- Live or pre-recorded audio/video stream reproducer
- Virtual Classroom
- Content research
- Application sharing
- Progress tracking
- Auto-evaluation tests
- Integration between progress record and didactic material delivery

The examined platforms have obtained the results showed in table 2.

Platform	Number of offered services
LearningSpace	11
WebCT	7
BlackBoard	7
Intralearn	9
Centra-Cisco	10
LearnLinc	9
Atena	7
Apriori	7
Training Office	5
Jets	4
Click2Learn	9
TopClass	10
Ecollege	8
Switchport	9
Docent	10

Table 2.   Services offered by each examined platform.

Starting from these data, some weights have been given to each service, thereby creating an index able to express a weighted evaluation of the offered services in respect of both our evaluation model and the value they have within the platform. Greater weights have been assigned to those services that increase collaboration among users and allow students to be active protagonists of their own training path. The obtained results are showed in the graph of figure 2.
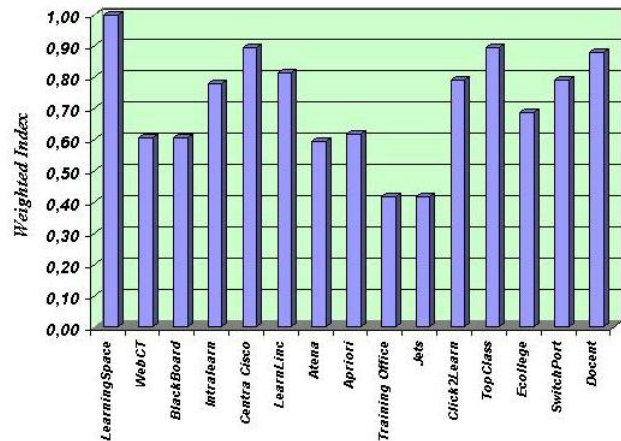

Figure 2: Weighted evaluation of the offered services

The table and the graph point out that the different e-learning software producers do not homogeneously foresee the presence of all tools. Such platforms as LearningSpace, Cisco-Centra and Topclass integrate a various and complete series of services and, from this point of view, represent the optimal solution for managing on-line courses. Such products as Jets or Training Office characterized by a scarce equipment take the consequences of their organization. Training Office has been developed to meet self-paced training within

industries and therefore it does not include tools (such as whiteboard or chat) for simulating the interactions usually present in a classroom. Jets is a platform designed in the academic field, therefore it does not aim to be exhaustive. In addition, it should be taken into account that not all the services offered by some platforms are proprietary and their availability is linked to other products availability. It is therefore useful to consider how many services are proprietary in a platform and how many are acquired by other products. The situation, always related to the previously listed services, is represented in the graph of figure 3.
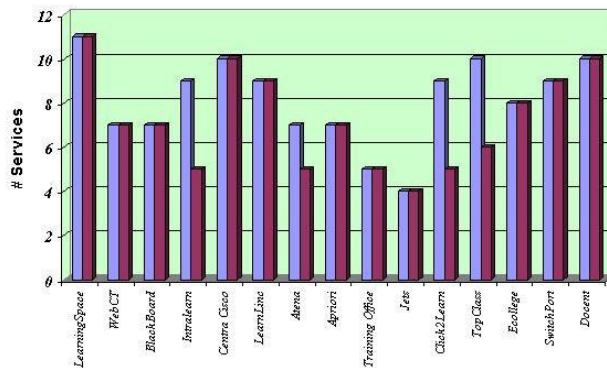
Figure 3: Index representing the number of proprietary services (in red) compared to the global offered services (in blue) offered by each examined platform

In general, platforms tend to integrate proprietary services, and use other producers' services only to manage synchronous and asynchronous services (such as e-mail). In particular, many platforms tend to use Microsoft NetMeeting application as for managing live audio/video stream. Besides services for facilitating learning, an on-line learning platform must implement functionalities for managing contents, courses, users and activity tracking. These functionalities are generally included in LMSs and LCMSs. Platforms including these systems are to be considered optimal compared with to those ignoring them, as they represent the core of a system for delivering on-line courses. Among the various functionalities that these systems can offer, a representative number of them has been defined, and these ones are those that, in our opinion, must be absolutely present in an on-line learning platform:

- *Progress Tracking;*
- *Multiple course management;*
- *Hypertextual courses;*
- *Student groups' creation and management*

- *Content inclusion in accordance with standards;*
- *Content importation;*
- *New course creation in accordance with standards;*
- *Course indexing;*
- *Course importation from other producers;*
- *Reports on course frequency or utilization;*
- *Test creation;*
- *Course catalogue;*
- *Multiple choice tests;*
- *Reports on test results;*
- *On-line registrations;*
- *Access rights assignment;*
- *Username and password assignment .*

In figure 4, for each examined platform, it is reported a functionality index defined by the relation between the functions supported by the platform and those taken for sample:

$$IF \text{ (management functionality index)} = \frac{\#\,offeredFunctions}{\#\,requiredFunctions}$$
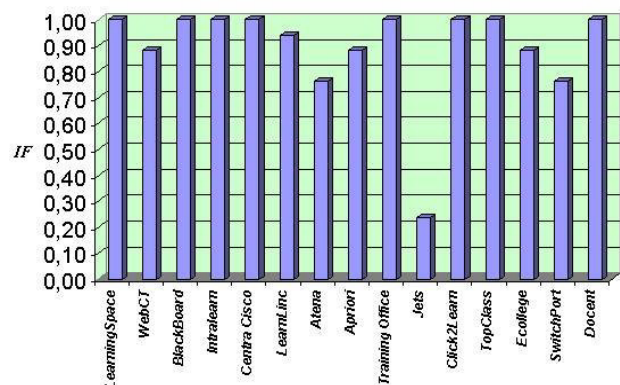
Figure 4: Index representing management functionality weight within platforms

This index weighs the ability of various platforms to manage and to update the course structure and the students' profile. As it can be deduced from the graph, almost all the platforms try to equip themselves with tools for managing users and contents. A characteristic shared by these platforms is the attempt to implement services for activity tracking in order to better organize the lessons on the basis of the user profile. However, these attempts often limit themselves to simple event registrations that do not become real improvements in content delivery quality.

Finally, we have tried to obtain a global evaluation index taking into account all the characteristics emerged from the evaluation of the macro fields, and accurately weighing each contribute. In particular, a greater weight has been assigned to the resources associated with the services offered to users distinguishing, anyway, the specific weighs of the same ones. Less importance has been given to system requisites, because each platform has shown an optimal architectural design and users are generally oriented to Windows operating systems. A medium weight has been given to the services associated with the training resource, course and user management, because, though destined to become the core of the future platforms, they are still immature. The obtained data have been accurately normalized to the maximum achievable value. Figure 5 reports the global evaluation index calculated for each examined platform.
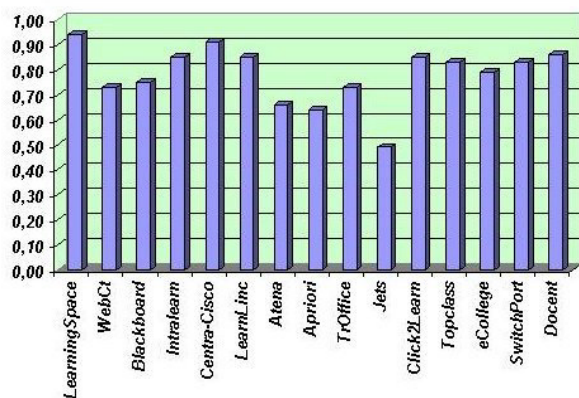
Figure 5: Global evaluation index

5. Conclusion

In order to accurately evaluate the potentialities of an on-line learning platform, it is important to pay attention to its three main components:

- *Learning Management System;*
- *Learning Content Management System;*
- *Virtual environment for teaching and services associated with it.*

An efficient system must be able to integrate into oneself all these components so that they can efficaciously interact with each other. It is important not to forget that both the LMS and LCMS are services that need to use database servers, which allow them to be efficiently managed. Besides, it is necessary that such platforms make reporting data services available, so as to allow accurate analyses on activities carried out by users. A typical architectural organization is a multi-layer one, which guarantees scalability, modularity and security. Almost all the platforms analysed by us show this approach. It is important to emphasise that content management is a factor that particularly affects the performances and costs of an e-learning platform. An LCMS allows to semi-automatically managing training contents. Standard use is a fundamental condition to achieve these objectives. Such solutions as Topclass deal with this problem in a very detailed manner, allowing an efficent content management. In general, platforms, which reach optimal performances in our evaluation, are equipped with content management systems (for example, Centra-Cisco, Blackboard, Intralearn, Click2learn). It is significant to point out that the LMS and LCMS are in some way complementary. This idea is confirmed by our evaluation, since it is evident that producers tend to realize systems able to integrate both the components. User collaboration services are very relevant too. In addition to such tools as e-mail, chat, and discussion forum, interest is nowadays turned to the realization of environments able to reproduce the mechanisms typical of a traditional classroom. Problems associated with training resource delivery mainly involve quality that is offered to users. Quality is generally linked to the band used by the transmitting channel and to efficiency of tools adopted for transmitting. The present trend is to allow an effective communication through Internet and Intranet networks making use of the IP protocol. Anyway, this choice poses some problems about stream continuity and event contemporaneousness. In the light of these considerations, it becomes natural for industries leader in producing network infrastructures (as Cisco) and industries leader in on-line learning (as Centra) to reach agreements. These "joint ventures" allow realizing innovative solutions, as Centra Cisco platform clearly shows. The analysed solutions have showed a medium quality. Learning Space and Centra-Cisco, the best ones in accordance with our evaluation, integrate into one product most of the functionalities concerning the LMS and LCMS, offering also a complete compatibility with standards and architectures. Click2learn, Topclass, WebCT, Blackboard and Intralearn also achieve significant results, but, unlike the previous ones, they have not powerful collaboration functionalities in real time. Click2learn and Intralearn are penalized since they use NetMeeting too much.

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