МЕТОДОЛОГИЯ ЗА ОЦЕНКА НА СИСТЕМИ ЗА УПРАВЛЕНИЕ НА ОБУЧЕНИЕТО, БАЗИРАНА НА СТЕПЕНТА НА ВЛИЯНИЕ НА ОЦЕНЯВАНИТЕ КОМПОНЕНТИ

Ивайло Благоев, Владимир Монов

METHODOLOGY FOR ASSESSMENT OF LEARNING MANAGEMENT SYSTEMS BASED ON THE IMPACT OF THE ASSESSED COMPONENTS

Ivaylo Blagoev, Vladimir Monov

Резюме: В настоящата статия се разглеждат и класифицират отделните изисквания към системите за управление обучението, на база на които да бъде извършена последваща оценка на самите системи. В разработката се анализират съществуващите модели за оценка, като на база на тях се извежда оптимизирана методология, съобразена със степента на влияние на всеки отделен оценъчен критерий и специфичния тип на обучителната организация внедряваща системите за управление на обучението. Разработени са скала за оценка на влиянието на отделните критерии за различните типове организации и скала за оценка на съответствието на оценяваната система за управление на съдържанието с отделните критерии.

Ключови думи: класификация на компонентите на системите за електронно обучение, оценка на системите за управление на обучението, сравнение на системите за електронно обучение.

Abstract: This article examines and classifies the individual requirements for the learning management systems, on the basis of which a subsequent assessment of the systems themselves could be carried out. The project analyzes the existing evaluation models based on an optimized methodology tailored to the degree of impact of each individual evaluation criterion and the specific type of the training organization implementing the training management systems. A scale for assessing the impact of individual criteria on the different types of organizations and a scale for assessing the compliance of the evaluated content management system with the individual criteria has been developed.

Keywords: classification of components of e-learning systems, evaluation of learning management systems, comparison of e-learning systems.

1. INTRODUCTION

The dynamic development of information and communication technologies has led to a dramatic increase in the number of Learning Management Systems (LMS). The creation of LMS is a result of the awareness of the potential opportunities of IT-based training by global corporations and leading universities. These systems enable business organizations to plan and analyze the needs of staff and their clients for training. LMS relate to the organization's global planning and management and are related to appraisal, selection and enhancement of staff qualifications. LMS also maintain a library of available courses, training materials and learning related events stored in a suitable work format. LMS are specialized training systems based on modern internet and web technologies [1]. On the other hand, it is believed that LMS arise due to the need to provide organizational, administrative and educational elements, as well as the inclusion of a variety of technological components [2]. LMS users cover the following categories [1]:

- *Learners* - using distance learning systems;
- *Instructors* - lecturers or their teams using training, coaching, learner support, attestation, monitoring and control systems.

- *Administrators* - supporting the seamless operation of systems and providing access to it to other users according to their specific rights.

LMS offer services that meet specific instructional needs and automation, where they perform four main tasks through an easy to use and unified user interface:

- *dissemination of information* - including news reporting, event calendar, dictionary, etc.;
- *management of educational materials* - personalization of the user interface according to the needs of the instructor for the renovation of the educational materials;
- *providing various communication channels* - both synchronous and asynchronous;
- *group work management* - task assignment for learners, online assessment and monitoring of learners, management of the learning process and the rights of the learners.

The development of learning management systems is primarily aimed at creating web based/browser-based platforms (without the need to install additional software from users). Web-based platforms are client-server applications in which the client (including user interface and client logic) works in a web browser [3]. From a business point of view, e-learning systems are divided into two main groups:

- *Commercial paid software applications* - mainly distributed on a subscription basis for a certain number of active users per unit of time;
- *Open Source Systems* - Open source systems are software that has been developed, tested, or enhanced through public co-operation, and is disseminated with the idea that it should be shared with others, ensuring open future collaboration [4].

The increase of the accessibility of more users to the Internet, the continuous growing in connection speed and the ever-increasing number of users using the Internet from mobile devices dramatically increases the number of training management systems. According to the captera.com authoritative site for comparison and ranking of software as of January 2018, the number of actively supported learning management systems is 381 [5]. The large number of systems requires the use of a methodology to analyze and compare the functionalities of the systems so that organizations willing to implement or purchase a training management system subscription can get a realistic assessment of the capabilities of any system, with the specific requirements of the organization.

2. ANALYSIS

Most of the methodologies developed to evaluate eLearning systems group the main criteria of category evaluation, and each evaluated system is then described whether it meets the requirements of the relevant criterion or not [6]. The breakdown of the evaluation criteria is mainly based on the different types of functional and technical possibilities, adding the criteria for financial evaluation. The main categories of assessment are communication tools, productivity tools, student engagement tools, administrative tools, learning content creation and management tools, hardware and software requirements, and pricing and licensing rights [7]. The major drawbacks of the methodologies described above are the following:

- insufficient detail of assessment based solely on the presence or absence of specific functionality;
- lack of a weighting factor that reflects the degree of impact of the assessed criterion on all other criteria;
- not taking into account the specific requirements and needs of organizations moving to learning management systems.

The present methodology proposes an algorithm for evaluation of learning management systems based on the specific needs of the different types of organizations, reflecting the respective degree of impact of the individual criteria and subsequent evaluation of the system under consideration based on the degree of compliance.

Categories of assessed criteria and relevant criteria have been developed to maximize the ability to obtain a comprehensive assessment of the capabilities of the system under consideration. All financial parameters remain outside the evaluated components, as the receipt of a real comprehensive valuation including financial data requires information about the price of the proposed system, possibly the cost of separate modules, as well as the period for which it will be used for subscription and the cost of implementation and integration services for open source systems. On the other hand, a real estimate of the rate of return on investment should also include information on the number of users who will use the system, the price of the courses if it will be used for training services to third parties or the increase in sales growth, due to the increased qualification of employees using the training management system for intra-corporate training. The financial efficiency of learning management systems is a separate direction in LMS assessment and is itself a subject of in-depth scientific research and therefore goes beyond the scope of this article and should be considered and evaluated irrespective of the technical and functional capabilities of training management systems.

3. METHODOLOGY FOR LMS ASSESSMENT

10 categories of criteria have been defined, and for the purpose of demonstrating the methodology, the individual criteria for two of them are evaluated in detail. The main categories used for the purposes of the methodology are presented below, and can be supplemented by the organization evaluating those that are highly specific to it.

1. **Security and access control** - ensuring the security of personal data, providing access to different types of users, defining access rights, etc.;
2. **Communication** - tools for communicating and collaborating among users, simulating to the maximum extent the learning process in the present form;
3. **Development of learning content** - tools for building learning content, multimedia and interactive resources, interacting to the maximum extent with the trainee;
4. **Evaluation** - a test complex that provides assessment of the knowledge, skills and competences of the learners, provides them with feedback and provides administrators with tools for analyzing and processing the results;
5. **Informing and notifications** - a virtual environment for receiving notifications and informing consumers about upcoming events, expiring deadlines, etc.;
6. **Reports and statistics** - tools for reporting and analyzing the attendance, progress and success rate of the trainees for each of the training courses and for the system as a whole.
7. **Design and multi-platform** - system design and usability, adaptive design with accessibility from different platforms and device sizes, mobile access applications, etc.;
8. **Speed-up** - system speed based on individual content types, quality management based on user connectivity speed, etc.
9. **Integrity** - tools for building integration with other systems, SCORM support, integration with human resources management systems and systems for authentication, etc.

10.   **Personalized / adaptive learning** - tools for building and delivering customized learning content and customized user learning path.

To assess the degree of impact of the individual assessment criteria, 11-step scale was developed to assess the degree of relevance of the assessed functionality to the specific needs of the organization.

Tab. 1. Assessment scale of the degree of impact of individual evaluation criteria.

Degree	Influence on the organization
0	Criterion (assessed functionality) affects a limited number of users (less than 20%) but does not affect the learning process at any degree
1	Criterion (assessed functionality) affects a limited number of users (less than 20%) and use is very rarely required
2	Criterion (assessed functionality) affects a limited number of users (less than 20%), but use is required often
3	Criterion (assessed functionality) affects a large number of users (over 20%) of the system, but use is rarely required
4	The criterion (assessed functionality) affects a large number of users (over 20%) but is not of prime importance for ensuring the learning process
5	Criterion (assessed functionality) affects a large number of users (over 20%) and use is often required
6	Criterion (assessed functionality) affects all system users, but is not critical to ensuring the learning process
7	Criterion (assessed functionality) does not affect users but is of paramount importance to the organization
8	Criterion (assessed functionality) affects a limited number of users (less than 20%), but is of paramount importance for ensuring the learning process
9	The criterion (assessed functionality) affects a large number of users (over 20%), and is of paramount importance for ensuring the learning process
10	Criterion (assessed functionality) affects all system users and is of paramount importance for ensuring the learning process

A system for transforming the degree of impact into a normalized weighting factor (0 to 100) has been developed, which is then used to obtain a numerical value of the system evaluated, based on the degree of compliance. The model allows the addition of an unlimited number of categories and evaluation criteria, according to the specifics of the user organization. The weighting factor (K_{inf}) for each criterion with a defined (organization-defined) degree of influence is calculated using the following formula:

$$K_{inf} = \frac{100}{\left(\sum_{k=1}^{n} D_{inf}\right)} \times D_{inf}$$, where:

- K_{inf} – the weighting factor for each criterion;
- D_{inf} – the degree of influence of the individual criterion;
- n – the number of all the criteria to be assessed.

The determination of the weight coefficient of the above formula is illustrated in Table. 2, for two sample organizations: business organization and university / college, for which the degree of influence of the individual criteria has been determined in advance.

As can be seen from Table 2, the degree of impact on the same indicator may vary according to both the type of organization and the organization-specific needs and goals. For example, the benchmark *"1.4 VPN Functioning of the Organization",* which for business organizations *"Does not affect consumers, but is particularly important to the organization",* has the corresponding degree of influence - *7 (seven)* university or college *"Influences on a limited number of users (less than 20%), but does not affect the learning process at all"* and has a corresponding degree of influence - *0 (zero).* The corresponding weight ratios, in the context of all the assessed criteria, are as follows: 6.36 - for business organizations and 0.00 for university or college.

Tab. 2. Assessment scale of the degree of impact of individual evaluation criteria.

№	Criteria	Organization 1 Example – Business organization (intra-corporate)		Organization n University / College	
		Degree of influence	**Weighting factor**	**Degree of influence**	**Weighting factor**
1	**Security and access control**		**63.64**		**45.71**
1.1	Ability to manage user types / roles	10	9.09	10	9.52
1.2	Automatic access to training based on different criteria	10	9.09	10	9.52
1.3	Different user access with the ability to record results	2	1.82	0	0.00
1.4	Functioning in an organization's VPN	7	6.36	0	0.00
1.5	Security of users' personal data	10	9.09	10	9.52
1.6	Protection from unauthorized access / hacker attacks	10	9.09	10	9.52
1.7	Security of confidential information	7	6.36	4	3.81
1.8	LDAP autentication	7	6.36	0	0.00
1.9	SSL support	7	6.36	4	3.81
2	**Communication**		**36.36**		**54.29**
2.1	Embedded messaging system	4	3.64	5	4.76
2.2	Email integration	10	9.09	10	9.52
2.3	Real-time Chat	4	3.64	4	3.81
2.4	Discussion Forums	5	4.55	5	4.76
2.5	Synchronous audio connectivity between users	4	3.64	9	8.57
2.6	Synchronous video connection between users	4	3.64	9	8.57

№	Type of organization:	Organization 1 Example – Business organization (intra-corporate)		Organization n University / College	
	Criteria	**Degree of influence**	**Weighting factor**	**Degree of influence**	**Weighting factor**
1	**Security and access control**		**63.64**		**45.71**
2.7	Virtual Whiteboard	3	2.73	6	5.71
2.8	Desktop sharing	3	2.73	6	5.71
2.9	File exchange	3	2.73	3	2.86

In order to evaluate a specific content management system, it is necessary to perform detailed testing and analysis of its functionalities corresponding to the assessed criterion. Compliance of the system with the defined criteria requirements for the assessed criterion cannot, in many cases, be unambiguously confirmed or rejected, and therefore a more detailed scale has to be used to reflect the degree of compliance for each criterion. For the purposes of the methodology, a 6-step compliance assessment scale has been developed.

Tab. 3. LMS compliance assessment scale for individual assessment criteria.

Degree	Level of compliance
0	It does not meet the criterion at all
1	It meets the requirements to a very small extent
2	Partly meets the given criterion, and the missing functionality cannot be compensated
3	Partly meets the given criterion, and the missing functionality can be compensated (further developed or by using additional plugins / modules)
4	It meets almost completely the given criterion, and the missing functionality is not essential
5	It fully meets the given criterion

To determine the normalized outcome for each evaluation criterion, it is necessary to take into account the degree of impact of the assessed criterion on the particular organization and the degree of compliance of the assessed component of the LMS against the requirements. For this purpose, the following formula is derived:

$$G_{ec} = K_{inf} \times \frac{G_{res}}{G_{max}}$$, where:

- G_{es} – the outcome of the LMS assessment for the individual criterion;
- K_{inf} – the weighting factor for the individual criterion;
- G_{res} – the degree of compliance of the assessed LMS for the individual criteria;

- G_{max} – the highest grade of the LMS compliance rating scale used for the individual evaluation criteria (G_{max} for the specific scale is 5 (five)).

The overall result of the system evaluated can be determined by the following formula:

$$G_{lms} = \left(\sum_{k=1}^{n} G_{ec} \right)$$, where:

- G_{lms} – the final result of the complex LMS assessment;
- n – the number of all the criteria to be assessed;
- G_{es} – the outcome of the LMS assessment for the individual criterion.

The formula for determining the final outcome of the LMS complex evaluation is applied in the following table, prioritizing the assessed severity of the assessed LMS for the individual criteria. For the purpose of demonstrating the methodology, an evaluation of the Moodle open source learning management system was assessed, assessing the degree of system compliance for each of the above criteria of *Security and Access Control* and *Communication* categories.

Tab. 4. Evaluation of LMS Moodle for the needs of Business organization (intra-corporate) and University / college.

		Assessed system:				Moodle		
Type of organization:		**Business organization**		**University/ College**				
№	**Criteria**	Degree of influence	Weighting factor	Degree of influence	Weighting factor	Assessed system - degree of compatibility with the criteria	Result Business organization	Result University / College
1	Security and access control		**63.64**		**45.71**		**60.00**	**43.81**
1.1	Ability to manage user types	10	9.09	10	9.52	5	9.09	9.52
1.2	Automatic access to training	10	9.09	10	9.52	4	7.27	7.62
1.3	Different user access with the ability to record results	2	1.82	0	0.00	0	0.00	0.00
1.4	Functioning in an organization's VPN	7	6.36	0	0.00	5	6.36	0.00
1.5	Security of users' personal data	10	9.09	10	9.52	5	9.09	9.52
1.6	Protection from unauthorized access / hacker attacks	10	9.09	10	9.52	5	9.09	9.52
1.7	Security of confidential information	7	6.36	4	3.81	5	6.36	3.81
1.8	LDAP autentication	7	6.36	0	0.00	5	6.36	0.00

№	Criteria	Business organization		University/ College		Assessed system - degree of compatibility with the criteria	Result Business organization	Result University / College
		Degree of influence	Weighting factor	Degree of influence	Weighting factor			
1.9	SSL support	7	6.36	4	3.81	5	6.36	3.81
2	**Communication**		**36.36**		**54.29**		**33.82**	**48.57**
2.1	Embedded messaging system	4	3.64	5	4.76	5	3.64	4.76
2.2	Email integration	10	9.09	10	9.52	5	9.09	9.52
2.3	Real-time Chat	4	3.64	4	3.81	5	3.64	3.81
2.4	Discussion Forums	5	4.55	5	4.76	5	4.55	4.76
2.5	Synchronous audio connectivity between users	4	3.64	9	8.57	4	2.91	6.86
2.6	Synchronous video connection between users	4	3.64	9	8.57	4	2.91	6.86
2.7	Virtual Whiteboard	3	2.73	6	5.71	4	2.18	4.57
2.8	Desktop sharing	3	2.73	6	5.71	4	2.18	4.57
2.9	File exchange	3	2.73	3	2.86	5	2.73	2.86
						Total result:	93.82	92.38

Assessed system: Moodle

In practice, according to the different profile of the organization, the impact of only one component of the system evaluated could lead to a significant difference in the final result of the system being assessed.

4. CONCLUSIONS

Evaluation of e-learning systems is a complex task that depends on many factors. In order to make the most effective and realistic assessment of LMS, it is necessary to differentiate the functional evaluation from the financial one. On the basis of the presented methodology, the evaluation should be performed on the basis of predefined criteria, broken down by categories, and the evaluator should take into account the specific needs of the organization and the purposes for which the system will be used. The analysis of the organization's specific needs is also needed at the next stage where the degree of impact of each of the criteria assessed is evaluated.

According to the developed methodology, in order to obtain a normalized weight of each criterion it is necessary to transform the degree of impact of the individual criterion into weighting factor. On the basis of the so prepared infrastructure assessment, it may proceed to tests and analysis of the individual learning management systems, and for each individual criterion and for each system the degree of compliance is determined. The result of the compliance analysis together with the weighting factor of the assessed criterion determines the final assessment for the relevant criterion. The complex final measurable outcome of the developed methodology is a sum of the estimates for each of the criteria.

In the methodology used in this article to perform a complex LMS assessment three main tasks are essential: 1. Performing a functional and technical evaluation without considering the financial parameters; 2. Determine the degree of impact of the assessed criteria on the organization's requirements. 3. Perform LMS analysis and evaluation, taking into account the degree of compliance of the system evaluated for each individual criterion.

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Информация за авторите:

Ивайло Благоев, докторант, БАН, Институт по информационни и комуникационни технологии, Департамент Моделиране и оптимизация, ул. Акад. Г. Бончев, бл. 2, офис 503, Тел.: 02 979 32 37, e-mail: ivo.blagoev@iit.bas.bg

Доц. д-р Владимир Монов, БАН, Институт по информационни и комуникационни технологии, Департамент Моделиране и оптимизация, ул. Акад. Г. Бончев, бл. 2, офис 503, Тел.: 02 979 24 74, e-mail: vmonov@iit.bas.bg

Contacts:

Ivaylo Blagoev, Postgraduate, BAS, Institute of Information and Communication Technologies, Department of "Modelling and Optimization", Acad. G. Bonchev St., Block 2, Office: Room 503, Sofia, 1113 Bulgaria, Phone: (+ 359 2) 979 32 37, e-mail: ivo.blagoev@iit.bas.bg

Assoc. Prof. Vladimir Monov, PhD, BAS, Institute of Information and Communication Technologies, Department of "Modelling and Optimization", Acad. G. Bonchev St., Block 2, Office: Room 503, Sofia, 1113 Bulgaria, Phone: (+ 359 2) 979 24 74, e-mail: vmonov@iit.bas.bg