Criteria and methodology for the evaluation of e-Learning management systems based on the specific needs of the organization

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***Abstract*—** The paper explores, classifies and defines the individual requirements for the e-learning management systems, based on these criteria, a comprehensive assessment of the compatibility of each of the evaluated e-learning systems can be made. This paper analyzes the existing evaluation models and based on them an optimized methodology has been made. The methodology takes into account the degree of impact of each individual evaluation criterion and the specific type of the training organization implementing the e-learning management systems. A detailed criteria list, 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 e-learning management system with the individual criteria has been developed.

***Keywords*—** evaluation of learning management systems (LMS), methodology for LMS assessment, organization's need based LMS evaluation, classification of components of e-learning systems.

I. 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 the employees 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].

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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 [3]:

- **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 evaluation 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 [4]. 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 [5].

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 learning management systems. According to the captera.com authoritative site for comparison and ranking of software as of September 2018, the number of actively supported learning management systems is 399 [6]. 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 learning management system subscription can get a realistic evaluation of the capabilities of any system, with the specific requirements of the organization.

II. 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 [7]. 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 evaluation 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 [8]. The major drawbacks of the methodologies described above are the following:

- insufficient detail of evaluation based solely on the presence or absence of specific functionality;
- lack of a weighting factor that reflects the degree of impact of the evaluated 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 evaluated criteria and relevant criteria have been developed to maximize the ability to obtain a comprehensive evaluation 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 learning management system for intra-corporate training. The financial efficiency of learning management systems is a separate direction in LMS evaluation 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 learning management systems.

III. Evaluation Criteria

Defining a comprehensive and complete list of evaluation criteria for an eLearning system is a complicated task with regard to the thousands of system functionalities on the one hand and the different profiles and the specific requirements of organizations performing the pre-implementation assessment. However, the evaluation of e-learning systems should take into account key categories of criteria, and for the purposes of our methodology, 10 categories of criteria have been developed. In order to ensure effective ex-post evaluation, organization applying the e-learning system needs to supplement the criteria by those that are highly specific to it.

- **Security, access control and speed optimization** - ensuring the security of personal data, providing access to different types of users, defining access rights, etc.:
  - Ability to manage user types/roles
  - Automatic access to trainings, based on different criteria
  - Different user access with the ability to record results
  - Functioning in an organization's VPN
  - Security of users' personal data
  - Protection from unauthorized access/hacker attacks
  - Security of confidential information
  - LDAP authentication
  - SSL support
  - Kerberos authentication
  - Access based on E-commerce payment
  - Multiple security layers and user authentication
  - Full application security including security enforcement at every login and page request
  - Enable learners to self-register from a list of available courses
  - Group creation and management
  - Available to users 24/7
  - Video based on user speed (adaptive download)
  - Cache tools (Memcache, Redis etc.)
- **Communication** - tools for communicating and collaborating among users, simulating to the maximum extent the learning process in the present form:
  - Embedded messaging system
  - Email integration
  - Real-time Chat
  - Discussion Forums
  - Synchronized audio connectivity between users
  - Synchronized video connection between users
  - Virtual Whiteboard
  - Desktop sharing
  - File exchange
  - Course commenting

- **Development and organizing of learning content (courses, modules, topics)** - tools for building learning content, multimedia and interactive resources, interacting to the maximum extent with the trainee:
  - WYSWYG editor
  - Create a single training item that can be displayed in multiple languages
  - Multimedia editor/plugins
  - Integrated authoring tool
  - Interactive video creation
  - Ability to create surveys
  - Tools for collaboration between content creators (adding a comments and task management)
  - Free e-learning elements library (cut-out people, cartoon characters, transparent elements, audio)
  - Integration with paid image and footage stock bank
  - Predefined content templates (slide or whole course)
  - Managing interaction based on user events/triggers
  - Creating individual learning path
  - Describing content based on competences
  - H5P integration (https://h5p.org/)
  - Mixed content (audio, video, text images in one page/slide)

- **Evaluation and Certification** - a test complex that provides evaluation of the knowledge, skills and competences of the learners, provides them with feedback and provides administrators with tools for analyzing and processing the results:
  - Quiz management module
  - Standard question types (close, multiple-choice, fill in the gaps, matching etc.)
  - Extended question types (drag&drop, flashcards etc.)
  - Import/Export questions (based on standards)
  - Question bank management
  - Individual or group assignments
  - Certificates of completion management module (templates, customization, auto-issuing, management);
  - Course evaluation (Survey/Quiz)
  - Assessment management module
  - Portfolio management

- **Informing and notifications** - a virtual environment for receiving notifications and informing consumers about upcoming events, expiring deadlines, etc.:
  - Automatic e-mail notifications regarding assignments (introduction, pending and overdue)
  - Automatic e-mail notifications regarding course events (enrolment, upcoming deadline, overdue)
  - Customizable notifications
  - Email notifications
  - SMS notifications
  - Integration with calendars (Outlook, Gmail etc.)

- **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:
  - Real-time reporting dashboard
  - Course reports (course completions, course enrolments, etc.)
  - Quiz reports (standards based and custom)
  - User reports (active users, certification completion, compliance completion, user login activity)
  - Custom user defined report tool
  - E-commerce reports (purchased courses, course payment by payment method, etc.)
  - Course survey reports (course satisfaction)
  - Report export & download
  - Ability to upload external training records
  - Automated report delivery
  - All data for active and inactive users always available

- **User experience, design and multi-platform** - system design and usability, adaptive design with accessibility from different platforms and device sizes, mobile access applications, etc.:
  - Clear log in form (If Single sign-on not used)
  - Intuitive navigation
  - Intuitive search
  - Engaging & visually appealing interface
  - Responsive design
  - Mobile learning delivery
  - iOS and Android Applications
  - Ability to access assigned courses
  - Clear visibility into learning progress (Progress bar)
  - Custom branding (White labelling)
  - Multi-language (Localization)
  - Offline course player
  - Multi-browser support

- **Integrity** - tools for building integration with other systems, SCORM support, integration with human resources management systems and systems for authentication, etc.:
  - SCORM 1.2- & 2004 or AICC - compliant courses support
  - Single sign-on
  - Open API
  - Integration with Document Management Systems
  - Integration with Human Resources Systems
  - AD integration

- **Personalized/adaptive learning and gamifications** - tools for building and delivering customized learning

content, customized user learning path:
- Manage dependences between courses (based on status or score)
- Manage dependences between different content pieces (resources or slides)
- Distribution of content based on user competences analyses and user interaction
- Activity points
- Badges
- Prizes
- Leaderboards
- User profiles and dashboards

- **Support** (Especially for software as a service based LMS platforms) – additional services that ensure sustainable development and quality:
  - Email support
  - Phone support
  - Support representative
  - System training included (Live, online, documentation)
  - Help desk
  - Product video tutorials
  - Ongoing technology support and maintenance
  - Ongoing technology enhancements and upgrades
  - Ongoing data storage and security
  - Training related to new feature enhancements

For the purpose of demonstrating the methodology, the 18 individual criteria for first two categories are evaluated in detail.

IV. Methodology for LMS evaluation

To assess the degree of impact of the individual evaluation criteria defined in previous section, 11-step scale was developed. It aims to assess the degree of relevance of the evaluated functionality to the specific needs of the organization.

Table 1. Evaluation scale of the degree of impact of individual evaluation criteria.

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

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

The determination of the weight coefficient of the above formula is illustrated in Table 2 (Appendix), 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 (Appendix), 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%), and 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 evaluated criteria, are as follows: 6.36 - for business organizations and 0.00 for university or college.

In order to evaluate a specific content management system, it is necessary to perform detailed testing and analysis of its functionalities corresponding to the evaluated criterion. Compliance of the system with the defined criteria requirements for the evaluated 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 evaluation scale has been developed.

Table 3. LMS compliance evaluation scale for individual evaluation 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 evaluated criterion on the particular organization and the degree of compliance of the evaluated component of the LMS against the requirements. For this purpose, the following formula is derived:

$$(2)\ G_{ec} = K_{inf} \times \frac{G_{res}}{G_{max}}, \text{ where:}$$

G_{es} – the outcome of the LMS evaluation for the individual criterion;
K_{inf} – the weighting factor for the individual criterion;
G_{res} – the degree of compliance of the evaluated 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:

$$(3)\ G_{lms} = \left(\sum_{k=1}^{n} G_{ec}\right), \text{ where:}$$

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

The formula for determining the final outcome of the LMS complex evaluation is applied in Table 4 (Appendix), prioritizing the evaluated severity of the evaluated LMS for the individual criteria. For the purpose of demonstrating the methodology, an evaluation of the Moodle open source learning management system was evaluated, assessing the degree of system compliance for each of the above criteria of Security, access control and speed optimization and Communication categories.

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 evaluated.

V. Conclusion

Evaluation of e-learning systems is a complex task that depends on many factors. In order to make the most effective and realistic evaluation 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 assessed criteria 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 evaluation, 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 evaluated criterion determines the final evaluation for the relevant criterion. The complex final measurable outcome of the developed methodology is a sum of the estimates for each of the criterion.

In the methodology developed in this article to perform a complex LMS evaluation 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 evaluated 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.

APPENDIX

Table 2. Evaluation scale of the degree of impact of individual evaluation criteria.

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, access control and speed optimization**		**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 authentication	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	Synchronized audio connectivity between users	4	3.64	9	8.57
2.6	Synchronized video connection between users	4	3.64	9	8.57
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

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

Evaluated system:						Moodle		
Type of organization:		**Business organization**		**University/ College**		**Evaluated system - degree of compatibility with the criteria**	**Result Business organization**	**Result University / College**
№	**Criteria**	**Degree of influence**	**Weighting factor**	**Degree of influence**	**Weighting factor**			
1	**Security, access control and speed optimization**		**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 access rights for single user 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 authentication	7	6.36	0	0.00	5	6.36	0.00
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	Synchronized audio connectivity between users	4	3.64	9	8.57	4	2.91	6.86
2.6	Synchronized 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**

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