

Development of a Set of Requirements for the Hardware and Software of LMS Services of the University

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Abstract—This article considers the issues of expert research to determine a set of requirements for the hardware and software of the key LMS services of the university. Expert questionnaires have been developed to determine categories, including indicators of the functioning of the University's LMS services. Based on the developed questionnaires, a survey of various user groups was conducted: developers, administrators, teachers and students. Based on the processing results, the final set of requirements for the LMS reference model was determined.

Keywords—learning management system, expert assessment, LMS services, online education, distance education, higher education

1 Introduction

Open the Due to the pandemic, there has been a dramatic increase in the use of the Learning management system (LMS) at all levels of education. LMS can be defined as an information technology system that provides instructors with the flexibility needed to create, maintain and update information related to courses hosted on the Internet on websites [1]. The LMS should have advanced functionality that includes: designing, sharing, delivering, managing and evaluating learning resources for all categories of users, as shown in work [2]. There are many benefits to using LMS in the educational process, including: organization of materials; organization of students' independent work; the ability to develop tests and assignments; the ability to monitor activities; and development of the assessment system [3].

Many researchers have studied the relationship between the satisfaction of different categories of users, mainly learners, teachers and moderators of distance learning systems (LMS), and their interaction with the LMS in distance learning. In the works [4-11] estimates of the interaction of students and teachers with the LMS (learning environment) are presented, proposals are identified, some platforms, components and factors that form a mixed environment are analyzed so that we can facilitate and optimize learning in order to improve the quality of the teaching process.

In the course of researching the area of LMS design and construction, three main research directions have been identified: LMS content detailing and assessment [1-4, 5-8,11-14], LMS as a Big Data Source [15-17].

As the review of the above studies shows, the emphasis is on the evaluation of online courses, on the satisfaction of existing LMS, or the LMS is presented as an add-on over different sources. This study is aimed at analyzing the development and construction of LMS, and assessing the requirements for LMS in the context of certain categories of users.

The purpose of this study is to develop a set of requirements for the hardware and software of the University LMS services based on expert research. To conduct the research, a project team was created, which included LMS developers, IT specialists and teachers. Research stages:

Stage 1: formation of a working group of experts from various categories

Stage 2 formation of a preliminary set of requirements by the members of the working group

Stage 3 formation of a preliminary questionnaire for a set of requirements for hardware and software services LMS University

Stage 4: conducting a survey and processing the results

Stage 5 - formation of an intermediate questionnaire

Stage 6: conducting a survey and processing the results

Stage 7 - the formation of the final set of requirements for the hardware and software of LMS services of the university.

2 Methodology

To create a model of a set of requirements for the hardware of the LMS services of the university, an expert assessment method was chosen. An expert assessment of the set of requirements for the hardware of the LMS services of the university involves dividing the set of requirements into categories, for groups of experts with different competencies. Requirements are divided into blocks according to the principle of the category of requirements and are presented to the respondent depending on his membership in the expert group. In addition, the coefficient of assessment of expert groups for the same category (block) of requirements is also different.

Six factors were selected as predictors of LMS user satisfaction and identified: groups of respondents, categories of requirements, belonging to categories of requirements, weighting coefficients of assessments by categories of requirements (Table 1).

The survey was carried out online in 2 stages:

1. formation of a preliminary set of requirements for LMS services for inclusion in the expert questionnaire (<https://docs.google.com/forms/d/e/1FAIpQLSdKogIjnrKaHHohhLL9vTC3nW6I8ANO8a2x6G6VG9GP5KJbYw/viewform>).
2. formation of an expert questionnaire for a set of requirements for LMS services (https://docs.google.com/forms/d/e/1FAIpQLSd6HjujNbxBzOkmIPyICGM0EHnq8vHVH_NU3zHq-4gylwaaQA/viewform).

Table 1. Table of coefficients

Expert group	Factors (P)						
	<i>Software and hardware</i>	<i>Control and monitoring</i>	<i>Course development</i>	<i>Learning management</i>	<i>Communication</i>	<i>Usability</i>	<i>Software and hardware</i>
IS developer	1	0,8	0,2	0,2	0,1	0,1	1
LMS administrator	0,8	1	0,8	0,8	0,2	0,2	0,8
Teacher	Not available	Not available	0,8	0,8	0,7	0,6	Not available
Student	Not available	Not available	Not available	Not available	0,8	0,9	Not available

A preliminary set of requirements, consisting of 63 criteria divided into 6 categories, describing the main criteria for an LMS, is shown in Figure 1.

An interim questionnaire was conducted among the members of the project group in order to determine the preliminary requirements for the expert questionnaire.

A five-point Likert scale was used. The scale ranged from (5: mandatory requirement) to (1: strongly redundant requirement).

The analysis of the results of the intermediate examination made it possible to form the main set of requirements, in accordance with the categories, by excluding two requirements from the list of preliminary ones:

1. Category 5, requirement 49;
2. Category 5 requirement 50.

having less than 50% of importance for inclusion in the main set of requirements of the expert questionnaire, falling out of the main spot of the distribution of estimates in Figure 2.

At this stage, 61 main criteria of the model for assessing the set of requirements for the software and hardware of the LMS services of the university were determined.

Based on the main set of requirements, an expert questionnaire was developed with the division of access to the categories of requirements depending on the competence of the expert groups.

The survey was conducted from December 2020 to March 2021 on the basis of the East Kazakhstan Technical University named after D. Serikbayev. The sample of respondents was 673 people, in the following categories:

- LMS administrator of the university - 32;
- teaching staff - 137;
- IS developer - 15;
- student - 489.

The questionnaire was pre-tested for reliability and validity with 23 students of distance learning (3rd year students) of East Kazakhstan Technical University. The results were analyzed to determine reliability using the Cronbach alpha method and received 0.71, which indicates an acceptable content of the questionnaire.

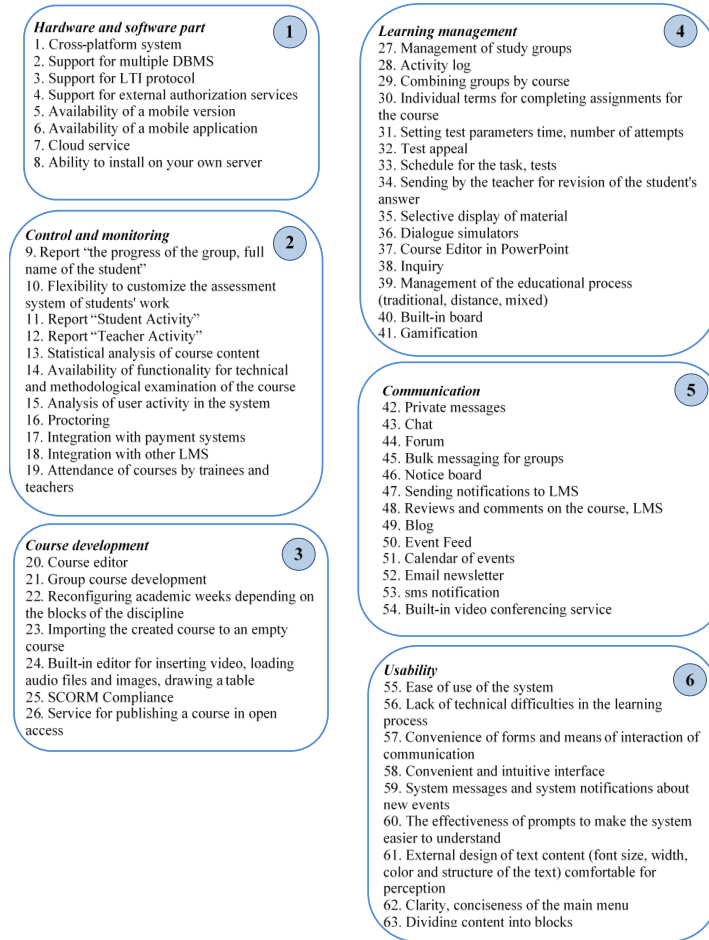


Fig. 1. Preliminary set of requirements

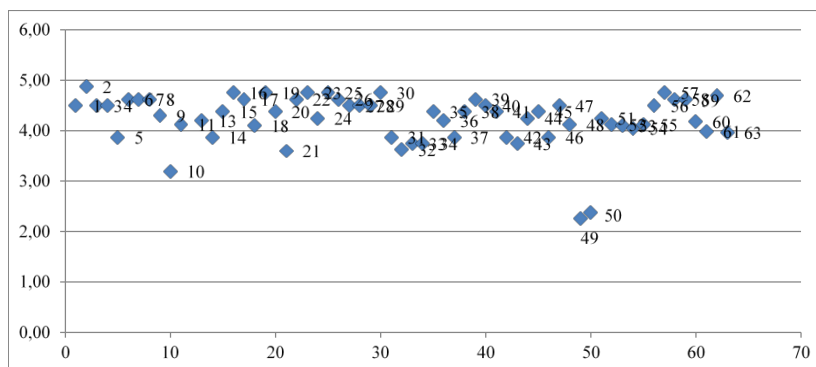


Fig. 2. Distribution of assessments of the requirements of the result of the interim questionnaire

The experts evaluated the necessary requirements for LMS in points from 0 to 3 (0-requirement is absolutely optional, 3-categorically mandatory requirement), taking into account the division of requirements into categories of requirements (Table 1).

The number of experts is denoted by m, and the number of evaluated requirements is denoted by n. The evaluated requirements are designated as B_1, B_2, \dots, B_n . The scores are summarized in a table similar to Table 2.

Table 2. Assessment of requirements in points

Expert number	Expert group Q	Category 1 G_1	Category 2 G_2	...	Category G G_g
		Requirement 1 B_1	Requirement B_2	...	Requirement n B_n
1	1-4	X_{111}	X_{121}	...	X_{1ng}
2	1-4	X_{211}	X_{221}	...	X_{2ng}
...	
M	1-4	X_{m11}	X_{m21}	...	X_{mng}

In Table 2, X_{ijk} is the score in points by the i-th expert of the j-th requirement, the k-th category of the requirement. The results obtained according to Table 2 are summarized in Table 3.

Table 3. Fragment of the results

B	P	$S_1 \cdot \sum B_{q/n}, q=1$	$S_2 \cdot \sum B_{q/n}, q=2$	$S_3 \cdot \sum B_{q/n}, q=3$	$S_4 \cdot \sum B_{q/n}, q=4$	$D_1 \cdot S_1 \cdot Y_{qk}, q=1$	$D_2 \cdot S_2 \cdot Y_{qk}, q=2$	$D_3 \cdot S_3 \cdot Y_{qk}, q=3$	$D_4 \cdot S_4 \cdot Y_{qk}, q=4$	$\sum D$	$R \cdot T/Y_k$
1	1	2,3	2,0			2,3	1,6			3,9	2,2
2	1	2,3	1,7			2,3	1,4			3,7	2,1
3	1	1,7	2,0			1,7	1,6			3,3	1,8
60	6	3,0	2,6	3,0	2,5	0,3	0,5	1,8	2,3	4,9	2,7
61	6	3,0	2,6	2,5	2,7	0,3	0,5	1,5	2,4	4,7	2,6

Where: S (1-4) - average values of assessments on demand (B), by a group of experts q (1-4); D (1-4) - the product of the average values of the estimates S (1-4) on demand (B), by a group of experts q (1-4) by the expert's coefficient q (1-4) of the factor P (1-6); T is the sum of the products D (1-4) of the average values of the estimates S (1-4) on demand (B), by a group of experts q (1-4) by the expert's coefficient q (1-4) of the factor P (1-6); R is the effective assessment of the requirement as a quotient of the sum of the products T by the sum of the coefficients of all expert groups by factor P (1-6).

The analysis of the examination results made it possible to form a set of requirements for the hardware and software of the LMS services of the university (Figure 3), in accordance with the categories, by excluding five requirements from the list (Figure 1):

1. Category 2, requirement 17;
2. Category 3, requirement 25;
3. Category 3, requirement 26;
4. Category 4, requirement 37;
5. Category 4, requirement 41;
6. Category 5, requirement 51;

having less than 70% of importance, falling out of the main spot of the distribution of estimates.

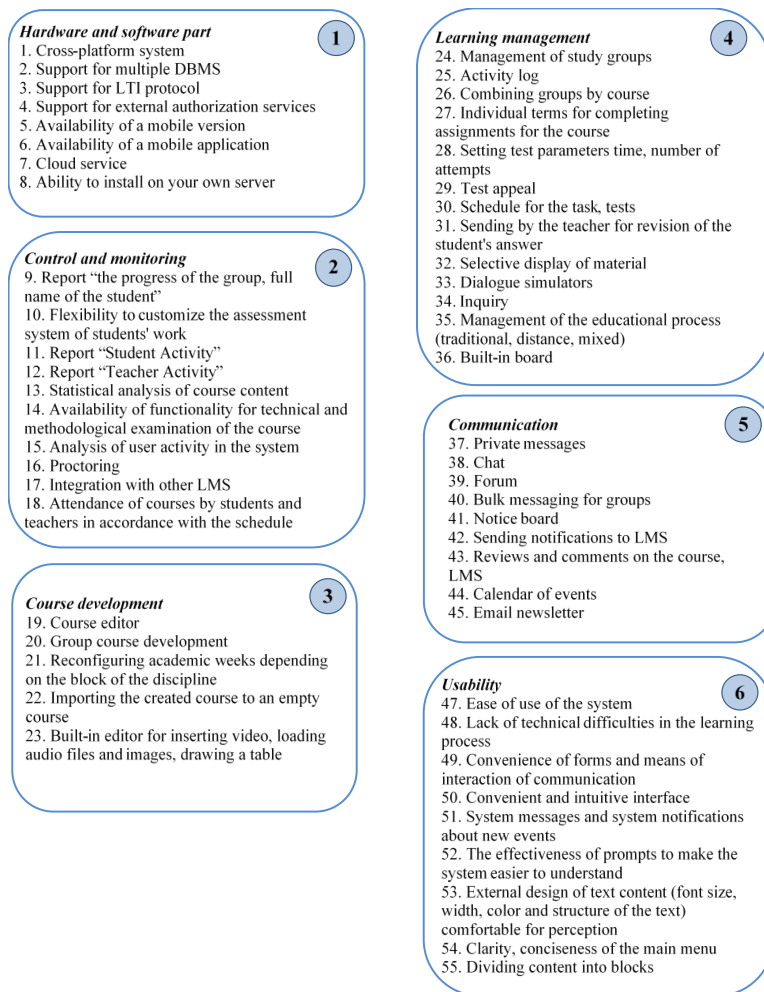


Fig. 3. Final set of requirements for LMS services

The formed criteria based on an expert survey reflect the basic requirements for the hardware and software of the University's LMS services.

3 Conclusion

The research carried out improves the quality of e-learning through multivariate analysis.

The research was carried out in several stages. The initial survey was conducted among the members of the project team, in order to determine a preliminary set of requirements for LMS services for inclusion in the expert questionnaire. The next stage of the questionnaire was carried out among 4 groups of experts in order to determine the main requirements and exclude minor requirements for evaluating the services of the LMS of the university. As a result, the final set of requirements for the hardware and software services of the reference LMS was obtained, which allows assessing the functionality of existing systems.

The results of this study will improve LMS services by providing different categories of users with a more efficient and demanded set of services. In particular, a set of requirements for the hardware and software of LMS services of the university was determined on the basis of expert research, including 55 criteria in 6 categories ("Software and hardware part", "Control and monitoring", "Development of courses", "Learning management", "Communication", "Usability").

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