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Quality assessment of the cloud-oriented environment for flipped learning of the future IT specialists

Olena Glazunova[1], Valentyna Korolchuk[2], Tetiana Voloshyna[3], Maksym Mokriiev[4]
[1]National University of Life and Environmental Sciences of Ukraine, Faculty of Information Technology, Ukraine, o-glazunova@nubip.edu.ua
[2]National University of Life and Environmental Sciences of Ukraine, Department of Information System and Technologies, Ukraine, korolchuk@nubip.edu.ua
[3]National University of Life and Environmental Sciences of Ukraine, Department of Information System and Technologies, Ukraine, t-voloshina@nubip.edu.ua
[4]National University of Life and Environmental Sciences of Ukraine, Department of Information System and Technologies, Ukraine, m.mokriiev@nubip.edu.ua

ABSTRACT

The article discusses the essence of the qualimetry approach and defines its role in the procedures for assessing the quality of the cloud-oriented environment for flipped learning in the process of training future IT specialists in higher education institutions. It offers a basic factor-qualimetry model for assessing the quality of such an environment, which can serve as a tool for its current monitoring and periodic review in the implementation of the internal quality assurance system of the educational process. The proposed basic factor-qualimetry model is based on the relevant criteria and indicators that have a specific weight. When building a factor-qualimetry model to assess the quality of the cloud-oriented environment for flipped learning of future IT professionals, 3 criteria and 26 evaluation indicators were identified, which were analyzed using the method of expert assessment. An example of calculating the quality of the environment is given. The obtained results allow to form individual approaches to the assessment of the quality of cloud-oriented environments, which are designed and applied in higher education institutions.

Key words: cloud-oriented environment, factor-qualimetry model, flipped learning, future IT specialists

1. INTRODUCTION

The current stage of development of higher education is associated with the transition to the practical implementation of a new educational paradigm, which aims to create a holistic system of continuous learning in the context of the extensive use of information technology, which allows to develop professional skills and soft skills. It is the use of modern cloud services and resources that enriches the process of training future information technology specialists in new ways and forms of organizing the educational process. Therefore, an important aspect in their training is the modern educational environment, which is based on the widespread use of information technology. Such an environment should include general tools for educational activities and special ones that are necessary for studying professionally-oriented disciplines for each specialty. Since a significant number of learning tools are available in the cloud, they need to be integrated into the University cloud-oriented educational environment. When selecting services for integration into the educational environ

ment, it is necessary to take into account the pedagogical technologies applied in the educational institution. The problem of assessing the functionality and effectiveness of the cloud-oriented educational environment, applied in the educational process, is not sufficiently solved in the application of various pedagogical technologies to ensure the educational process of various specialties, in particular for flipped learning of future IT specialists. Therefore, the aim of this article is to develop a factor-qualimetry model for assessing the quality of the cloud-oriented environment for flipped learning in the process of training future IT specialists in higher education institutions.

2. BACKGROUND AND RESEARCH PROBLEM

The revolution propelled by innovation in computer technology has widened the scope of e-learning and teaching, whereby the process of exchanging information has been made simple, transparent, and effective. The e-learning system depends on different success factors from diverse points of view such as system, support from the institution, instructor, and student [7].
The study by S. Ozkan and R. Koseler proposes a conceptual e-learning assessment model, hexagonal e-learning assessment model (HELAM) suggesting a multi-dimensional

approach for LMS evaluation via six dimensions: (1) system quality, (2) service quality, (3) content quality, (4) learner perspective, (5) instructor attitudes, and (6) supportive issues [8].

The paper [1] presents the concept of using qualimetry models in e-learning systems. The competence-based qualimetry model of the student, taking into account the dynamics of academic achievements, as well as the qualimetry model of a comprehensive assessment of the quality of electronic educational content is considered.

K. Kolos suggests the use of the constructed factor-criterion model for evaluating the effectiveness of computer-oriented learning environment of postgraduate teacher training institutions, which provides a criterion-based measurement of environment effectiveness according to four factors: 1) the effectiveness of advanced training courses for teachers in computer-based learning environment; 2) adequacy of environmental infrastructure; 3) ICT competence of academic staff; 4) students' ICT competence [5].

The article [1] presents the discourse of the "monitoring technology" concept; it reveals the essence, structure and content of qualimetric grounds of monitoring technologies in the educational process of the University. The study identifies and determines the effectiveness of the implementation of the following qualimetric grounds of monitoring technologies into the University educational process: 1) goal; 2) functions; 3) principles; 4) complex of monitoring tools.

N. Badrtdinov and D. Gorobets developed an assessment model to identify management efficiency of an educational establishment on the basis of the distinguished parameters, factors and criteria, on the basis of the factor-criterion model. The authors distinguished two groups of parameters of management efficiency of a higher educational institution: 1) parameters that characterize activity of an institution: economic efficiency, social efficiency, quality of education; 2) parameters that characterize management: orientation on innovations, human resources policy, and management system of an educational establishment. Selected parameters in this model are specified by factors and criteria [6].

3. THE PRESENTATION OF THE MAIN RESEARCH AND EXPLANATION OF SCIENTIFIC RESULTS

The National University of Life and Environmental Sciences of Ukraine (NUBiP) has designed a cloud-oriented environment for training future IT specialists by applying the flipped learning technology [1], which provides IT students with a set of different types of resources and services that allow them to use:

– *prior to classes within the framework of independent work with e-resources*: e-learning courses (ELC) in accordance with the curriculum for training specialists using the LMS Moodle platform; Khan Academy; online courses from Microsoft and Cisco leading technology companies, respectively, Microsoft Imagine Academy, Cisco Networking Academy; Massive Open Online courses (MOOC), such as Coursera, Udemy, Prometheus, edX, Khan Academy and others;

– *in the classroom*: professionally-oriented software and cloud services, namely: Microsoft Office 365; Visual Studio; draw.io; services for collective IT development (GitHub, Bitbucked, DeployBot, Phabricator, BeanStalk); Miro;

– *for the cooperation outside the university, services to manage collective projects such as*: Microsoft Teams, Jira, Trello, Asana, YouTrack.

Table 1 identifies the activities during the implementation of each phase of collective projects, in which students develop professional, integrated, self-educational competences and soft skills using a cloud-oriented environment for flipped learning.

Table 1: Process approach in using the flipped learning cloud-oriented environment in training future IT specialists

Process 1. Prior to classes	Content of the phase: Statement of the problem and elaboration of theoretical material	
	Activity	Teacher: preparation of theoretical material in accordance with the objectives of the project; selection of mass open online courses and recommendations for students Student: study of theoretical material in ELC; registration and selection of MOOC; taking online courses
	Forms	independent work; lectures (in-depth study)
	Methods	problem-solving, flipped learning
	E-content	LMS Moodle; MOOCs (Cisco Networking Academy; Prometheus; Coursera; Microsoft Imagine Academy; Udemy; Khan Academy)
	Means	professional communities
	Competences	self-educational; professional; ability to search, process and analyze information from various sources
	Result: acquaintance with the recommended professionally-oriented software and services for project management, taking online courses for acquiring theoretical knowledge and practical skills	

Process 2. In the classroom	Content of the phase: structuring the task, assigning roles and inserting deadlines, completing the basic tasks of the project	
	Activity	Teacher: setting a project task, advising teams on problematic issues, assessing the implementation of basic tasks Student: assessment of task complexity; search for solutions to the problem; division of tasks into separate tasks; distribution of roles and areas of responsibility of each team member; identification of those responsible for each task; determination of terms of performance of each task; solving practical tasks in accordance with the purpose of the task; consulting the teacher on problematic issues
	Forms	interactive lectures, laboratory classes, team development
	Methods	problem-solving, teamwork, flipped learning
	E-content	LMS Moodle
	Means	services for IT project management: Microsoft Teams; Jira; Trello; Asana; YouTrack services for team IT development: GitHub; Bitbucked; DeployBot; Fabricator; BeanStalk; professionally-oriented software
	Competences	ability to work in a team; knowledge and understanding of the subject area; ability to make decisions; professional and integral competences; ability to apply knowledge in practical situations
	Result: acquisition of basic skills while performing specific tasks through the application of professionally-oriented software and services of the cloud-oriented environment of the university	
Process 3. After classes	Content of the phase: Collective work of the team to perform the task and present the results	
	Activity	Teacher: monitoring the work of teams, performance assessment Student: team development, interaction with the team, presentation of results
	Forms	online communication, team development
	Methods	project activities, collaboration, flipped learning
	E-content	LMS Moodle
	Means	services for team IT development: GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software services for IT project management: Microsoft Teams; Jira; Trello; Asana; YouTrack
	Competence	professional; integral; ability to apply knowledge in practical situations; ability to be critical and self-critical; ability to assess and ensure the quality of the work performed; ability to visualize, formulate, solve problem situations, making the right decisions, taking into account the available information; ability to present the project to investors or your own team
	Result: presentation of project results, assessment of project readiness for implementation	

The qualimetric approach was chosen as the basis of the factor-criterion model for assessing the quality of the cloud-oriented University environment, which applies flipped learning. Qualimetry is a branch of science that studies the problems of methodology and comprehensive quantitative assessments of the quality of any objects: things or processes [4].

The structure of the factor-qualimetry model for assessing the quality of the cloud-oriented environment for flipped learning is presented in Figure 1.

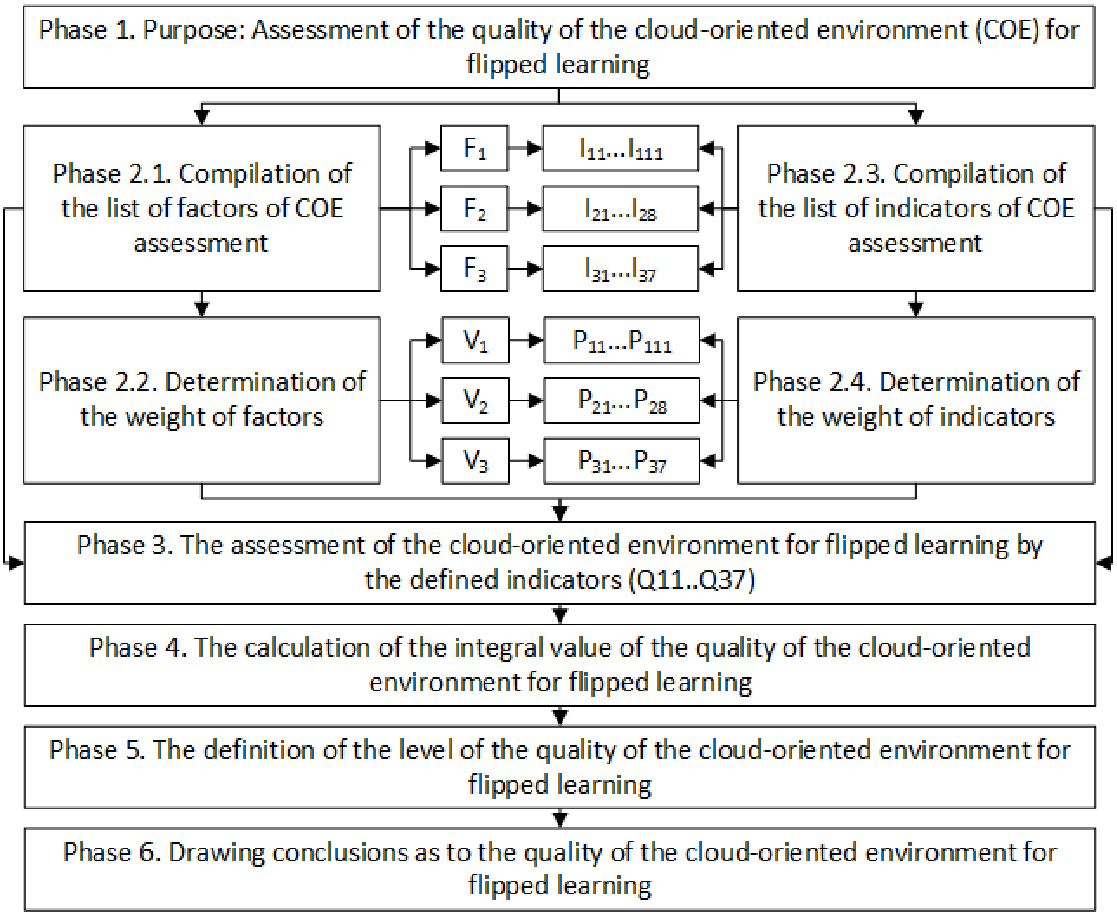

Figure 1: The diagram of the factor-qualimetry model for assessing the quality of the cloud-oriented environment for flipped learning

The target of assessing the quality of the cloud-oriented environment for flipped learning in the course of training future IT specialists is substantiated at the first phase. At the second stage (2.1-2.4) the list of factors of their assessment is formed, namely the efficiency of: (F1) the cloud-oriented environment; (F2) the cloud-oriented environment for the flipped learning technology; (F3) the cloud-oriented environment for project activities. For each of them a factor-criterion model is developed according to which assessment is carried out by the defined indicators (I11...I37), which serve as a quantitative indicator of the quality of each factor (Phase 3). Accordingly, the calculation of the integral value of the quality of the cloud-oriented environment for flipped learning by the defined indicators (Q11...Q37) takes place at Phase 4. At Phase 5 the level of the quality of the cloud-oriented environment for the flipped learning is defined under the assessment scale. If the sum of all the results of the quality assessment of the environment for all factors is greater than the threshold level, then the cloud-oriented environment for flipped learning is classified as the highest quality level (Phase 6).

4. RESULTS OF RESEARCH

To assess the quality of the cloud-oriented environment for flipped learning, a factor-qualimetry model for assessing the quality of such an environment is developed, which is presented in Table 2. This model selects 3 assessment factors that must be considered when designing such an environment, namely: performance of the cloud-oriented environment, effectiveness of the cloud-oriented environment for the project activity and effectiveness of a cloud-oriented environment for flipped learning. The indicators of assessing the cloud-oriented environment are defined for each of the factors according to 3 factors and their weighted coefficients, the list of them is formed and the weighted coefficient of each is determined [3]. Since the flipped learning method is usually used in conjunction with the project method, when designing a cloud-oriented environment for flipped learning in higher educational institutions, it is necessary to take into account its convenience for flipped learning, for project learning, and overall productivity of such an environment. That is why all the factors of the proposed factor-criterion model are equilibrium.

Table 2: Factor-criterion model for assessing the quality of a cloud-oriented environment for flipped learning (QCOE)

Factor (Fk)	Weighted factor (Vk)	Indicators (Iki)	Weighted factor of the indicator (Pki)	Quality value (Qki)	
Factor 1 – performance of the cloud-oriented environment $F_1 - \sum_{i=1}^{11} P_{1i} * Q_{1i}$	V1 = 0.333	I11 - accessibility (ability to work from any device)	P11 = 0.09	Q11	high – 1; acceptable – 0,75; critical – 0,35; unsatisfactory – 0
		I12 - reliability (high-quality functioning of the cloud-oriented environment)	P12 = 0.05	Q12	
		I13 - flexibility (designed and used in line with learning objectives)	P13 = 0.09	Q13	
		I14 - expediency (need for use to solve problems)	P14 = 0.04	Q14	
		I15 - convenience (clarity and ease of use)	P15 = 0.06	Q15	
		I16 - support for processes (communication, collaboration, cooperation, planning and control)	P16 = 0.17	Q16	
		I17 - teamwork (the ability to organize teamwork, create team projects)	P17 = 0.10	Q17	
		I18 - integrity (ensuring a continuous educational process)	P18 = 0.04	Q18	
		I19 - integration with other cloud services	P19 = 0.13	Q19	
		I110 - support of various programming technologies	P110 = 0.09	Q110	
		I111 - the ability to access open code software	P111 = 0.05	Q111	
Factor 2 – effectiveness of the cloud-oriented environment for the project activity $F_2 = \sum_{i=1}^{8} P_{2i} * Q_{2i}$	V2 = 0.333	I21 - ease of teamwork organization	P21 = 0.23	Q21	high – 1; acceptable – 0,75; critical – 0,35; unsatisfactory – 0
		I22 - convenience in planning the work on a collaborative project	P22 = 0.13	Q22	
		I23 - ease of roles and areas of responsibility allocation for each team member	P23 = 0.04	Q23	
		I24 - convenience of controlling the timing of each task	P24 = 0.08	Q24	
		I25 - convenience of communication among the team members	P25 = 0.10	Q25	
		I26 - ease of interaction of team members during team development	P26 = 0.22	Q26	
		I27 - ease of checking completed tasks	P27 = 0.04	Q27	
		I28 - ease of managing software (program code) versions	P28 = 0.17	Q28	
Factor 3 – effectiveness of the cloud-oriented environment for flipped learning $F_3 = \sum_{i=1}^{7} P_{3i} * Q_{3i}$	V3 = 0.333	I31 - availability of training resources in a cloud-oriented environment	P31 = 0.18	Q31	high – 1; acceptable – 0,75; critical – 0,35; unsatisfactory – 0
		I32 - completeness of educational material for students to acquire theoretical knowledge independently	P32 = 0.08	Q32	
		I33 - completeness of training material necessary for practical tasks	P33 = 0.24	Q33	
		I34 - convenience for independent preparation for the class	P34 = 0,12	Q34	
		I35 - convenience of interaction of team members in practical activity	P35 = 0,11	Q35	
		I36 - possibility of self-control	P36 = 0,20	Q36	
		I37 - convenience for checking	P37 = 0,08	Q37	

To assess the quality of the cloud-oriented environment for flipped learning, designed in a higher education institution, it is necessary to assess the environment for each of the identified indicators on a 4-point scale, namely: 1 – high value of the quality of the indicator; 0.75 – acceptable value of the quality of the indicator; 0.35 – critical value of the quality of the indicator and 0 – unsatisfactory value of the quality of the indicator. The assessment of the quality of the environment for each of the three factors is calculated as the sum of the products of the weighted indicators on the indicator of its development. The overall quality assessment of the cloud-oriented environment for flipped learning is calculated by the formula:

$$\mathrm{QCOE} = \sum_{k=1}^{3} F_k * V_k$$

The assessment scale provides for the final result of four levels of quality of the cloud-oriented environment:

– from 0 to 0.34 – the quality level of the cloud-oriented environment does not meet the requirements;
– from 0.35 to 0.49 – the quality level of the cloud-oriented environment is critical,
– from 0.5 to 0.74 – the quality level of the cloud-oriented environment meets the requirements (acceptable);
– from 0.75 to 1.00 – the quality level of the cloud-oriented environment is high.

To assess the environment of flipped learning, presented by us, the expert assessment was conducted, in which 42 experts, including both the academic staff and the students of the National University of Life and Environmental Sciences of Ukraine, took part. The expert group was selected from among the active users of the environment. Factor-criterion model for assessing such an environment is presented in Table 3.

Table 3: Factor-criterion model for assessing the quality of a cloud-oriented environment for flipped learning (QCOE)

Factor (Fk)	Factor assessment	Indicator assessment	Weighted factor of the indicator	Index of the quality value
Factor 1 – performance of the cloud-oriented environment	F1 = 0,76	I11 = 0.07	P11 = 0.09	Q11 = 0.81
		I12 = 0.04	P12 = 0.05	Q12 = 0.84
		I13 = 0.07	P13 = 0.09	Q13 = 0.77
		I14 = 0.04	P14 = 0.04	Q14 = 0.94
		I15 = 0.05	P15 = 0.06	Q15 = 0.85
		I16 = 0.15	P16 = 0.17	Q16 = 0.87
		I17 = 0.09	P17 = 0.10	Q17 = 0.92
		I18 = 0.03	P18 = 0.04	Q18 = 0.87
		I19 = 0.10	P19 = 0.13	Q19 = 0.79
		I110 = 0.07	P110 = 0.09	Q110 = 0.82
		I111 = 0.04	P111 = 0.05	Q111 = 0.79
Factor 2 – effectiveness of the cloud-oriented environment for the project activity	F2 = 0,81	I21 = 0.19	P21 = 0.23	Q21 = 0.82
		I22 = 0.10	P22 = 0.13	Q22 = 0.79
		I23 = 0.04	P23 = 0.04	Q23 = 0.91
		I24 = 0.07	P24 = 0.08	Q24 = 0.85
		I25 = 0.08	P25 = 0.10	Q25 = 0.84
		I26 = 0.16	P26 = 0.22	Q26 = 0.73
		I27 = 0.04	P27 = 0.04	Q27 = 0.96
		I28 = 0.14	P28 = 0.17	Q28 = 0.83
Factor 3 – effectiveness of the cloud-oriented environment for flipped learning	F3 = 0,84	I31 = 0.17	P31 = 0.18	Q31 = 0.93
		I32 = 0.07	P32 = 0.08	Q32 = 0.89
		I33 = 0.20	P33 = 0.24	Q33 = 0.83
		I34 = 0.09	P34 = 0.12	Q34 = 0.74
		I35 = 0.10	P35 = 0.11	Q35 = 0.88
		I36 = 0.15	P36 = 0.20	Q36 = 0.76
		I37 = 0.06	P37 = 0.08	Q37 = 0.79

Using the concordance coefficient, the degree of agreement of experts' opinions was assessed as quite high. The general assessment of the quality of the cloud-oriented environment for flipped learning designed at the National University of

Life and Environmental Sciences of Ukraine is:

$$QCOE = 0,76 * 0,333 + 0,82 * 0,333 + 0,84 * 0,33 = 0,81$$

The sum of all the obtained results of the assessment of the environment quality for all factors is greater than the threshold level, namely, it is equal to 0.81. Thus, such a cloud-oriented environment for flipped learning belongs to the category of the highest level of quality. Factor-qualimetry model of quality assessment of the cloud-oriented environment makes it possible to carry out external (expert) assessment; it also serves as a tool for self-assessment of its implementation. This cloud-oriented environment assessment tool provides a basis for current monitoring and periodic review of their quality for continuous improvement.

5. CONCLUSIONS

The need for an objective assessment of the quality of the cloud-oriented environment for flipped learning in higher education institutions has led to a comprehensive development and description of quality assessment of the effectiveness of the university environment. For this purpose, it is proposed to use the developed factor-qualimetry model for assessing the quality of the cloud-oriented environment, which provides a criterion for measuring efficiency according to three factors: 1) performance of the cloud-oriented environment; 2) effectiveness of the cloud-oriented environment for the project activity; 3) effectiveness of the cloud-oriented environment for flipped learning.

We see the directions for future research in the development of qualimetry submodels for assessing the quality of various components of the cloud-oriented environment of higher education institutions.

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