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E-LEARNING SYSTEM DEVELOPMENT AND IMPLEMENTATION: UNIVERSITY EXPERIENCE

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Abstract: The results of the design, development and implementation of the non-commercial e-learning system at Dniprovsk State Technical University (Ukraine) are presented in the paper. The developed system made it possible to organize the transition from face-to-face to on-line distance learning within the shortest possible time. For the successful system creation, the following stages had been performed: the data domain requirements analysis, system design, software construction, testing. implementation and maintenance. The university blended-learning model, which operated before the introduction of quarantine, and the developed e-learning system information model are presented in the paper. The models display the functional and structural data domain features, determine the roles, functions and available actions for the system users. The proposed e-learning system model consists of five components: e-content, discussion board, evaluation, collaboration and reflection. The constituent models parts implementation through the system user interface made it possible to provide the functions of asynchronous communication, collective and personal interaction, distribution of educational e-content, assessment of learning outcomes, statistical data accumulation and processing.

Keywords: e-learning system, distance learning, higher institution, design, implementation experience.

INTRODUCTION

The rapid development of information technologies, means of communications and the Internet gave impetus to the development of new ways of the distance learning (DL) organizing. DL is a form of learning whereby the source and recipient of knowledge are at a physical distance from each other, and > 80% of educational content is delivered by post and / or other tools for bridging the distance (Gorska, 2016; Sadeghi, 2019). The Internet using has made it possible to transform the methods of remote interaction between participants of the educational process: from sending educational materials by mail to organizing virtual classrooms. The learning for which $\geq 80\%$ of the content is delivered only via Internet and specialized software is called online or e-learning (Distance Education in European Higher Education, 2015; Fryan et al., 2013). The pandemic caused by the disease COVID-19 has created a number of challenges not only for government and health care system, but also for educational institutions of all types. According to the Resolution of the Ukrainian Cabinet of Ministers dd. 11.03.2020 № 211, all educational institutions have been transferred to DL to prevent the spread of COVID-19. Dniprovsk State Technical University (DSTU), Ukraine is a fourth-degree accredited higher education institution (HEI) that provides educational services for applicants of the bachelor' and master's level, trains PhD and postdoctoral programs (Friedman & Trines, 2019). The guarantine was introduced in DSTU by the Decree No 176 dd. 12.03.2020 and it has been still continuing. The introduction of quarantine restrictions implied a transition to 100% online interaction in the educational process. In this connection, the question arose about choosing methods and technologies for organizing DL to ensure the implementation of the educational process schedule in accordance with the approved class schedule and curricula of specialties. This work presents the results of the design, development and implementation of the e-learning system (ELS) in DSTU.

The research objectives were as follows:

- 1. Analysis of methods in, and international experience of, transition from faceto-face to distance online learning.
- 2. Building a blended-learning model describing features of the university education system, which had been functioning before the quarantine restrictions introduction.
- 3. Development of the ELS information model for DSTU, which forms the basis for its software implementation and distance online learning (DOL) organisation.
- 4. Description of the ELS implementation features.

1. INTERNATIONAL EXPERIENCE IN DISTANCE ONLINE LEARNING ORGANIZING

Universities around the world are launching and promoting various types of online learning, and the topic of information and communication technologies effective use remains relevant and leading scientific and practical task.

In general terms, it is expedient to describe two main ways of DOL launching in HEIs, namely:

- Use of commercial and non-commercial software products. The national researches on e-learning launching were describe in numerous works of the scientists such as: Alkhalaf, Drew, AlGhamadi, Alfarraj, Gorska, Al-adwan, Smedley, Thowfeek, Jaafar, Benta, Bologa, Dzitac, Dzitac. The works of scientists teams describe the results of complex studies and comparative characteristics of the learning manager systems (LMS) implementation results in various countries: African countries (Kituyi & Tusubira, 2013); countries of the Middle East (Azawei, Parslow, & Lundqvist, 2016); European countries (Vasilevska et al., 2017; Fidalgo et al., 2020; Zormanova, 2016; Kommers et al., 2014; Falfushynska et al., 2019). In Ukraine, such scientists as: Morze, Buhaichuk, Korotun, Kademiia, Koziar, Kukharenko, and many others are engaged in the process of the effective DOL organizing. Most of the works, describing experience of DOL launching and usage in universities, are devoted to the results of LMS Moodle launching (Shcherbyna, 2020).
- 2. Development and launching of its own university software products. Kituyi and Tusubira (2013) in their work describe the framework for the e-learning integration in HEIs. The results of the successful development and implementation of its own ELS into Hashemite University educational process in Kingdom of Saudi Arabia are presented in the work of Dutta, Mosley and Akhtar (2011). One of the most famous and successful examples of own university software product, implementing DOL, is the MOOC EdX platform, developed in 2012 by Harvard University in cooperation with the Massachusetts Institute of Technology (USA) (Baran, Baraniuk, Oppenheim, Prandoni, & Vetterli, 2016).

At the time of the quarantine introduction, DSTU was implementing one of the types of DL – blended learning that provides a combination of e-learning and traditional face-to-face learning (Oliinyk, Filipova, & Shelestova, 2019). Distribution of e-content was carried out through the university informational portal – the non-commercial software of its own production.

In the 2019–2020 academic year more than 2000 students had been studying at DSTU. The training had been carried out in 21 bachelor specialties, 19 master specialties and 10 specialties of PhD training at 25 university departments. About 90% of students are full-time students, therefore, the task of providing uninterrupted learning, a quick and effective transition to a DOL, ensuring the development of general and special competencies, is a difficult and extremely urgent task.

2. E-LEARNING SYSTEM MODELLING

According to software engineering standards, the life cycle of the ELS consists of five mandatory stages: requirements and data domain (DD) analysis, design, software implementation, testing and operation. The purpose of the ELS requirements analysis was: to obtain maximum information about the methodological and technical requirements, to define an expected effect from the ELS implementation.

It is advisable to present the results of the DD analysis in the form of its models, which allow displaying the system from the functional and structural sides.

2.1. Blended-learning information model before the e-learning system implementing

One of the ELS requirement was the necessity to preserve and ensure the further functioning of the available software tools that had been already used to organize remote interaction of participants in the educational process. DSTU informational portal (URL: http://www.dstu.dp.ua/Portal/WWW). The informational portal has been functioning at DSTU since 2011. The purpose of its creation was to organize a structured repository of educational e-content, created by DSTU teachers, with the possibility of sharing, viewing and downloading. During the transition to DL, it could be used as a knowledge base, but it was not able to independently perform all the functions of DOL. Figure 1 illustrates the fragment of graphical model presentation, describing DD features before the ELS introduction.



Figure 1. Module Introduction of Distance Courses Source: Own work.

The blended learning information model development provided an opportunity to present the existing structure of the site and informational portal. The purpose of model creation is to determine the points of data flows input and output, data sources and receivers; to form specifications of missing functions for the effective DOL implementation. The detailed description of the informational portal functions, its structure and modalities of operation are presented in the work (Yalova, Zavgorodnii, Romaniukha, Capay, & Drlik, 2014).

2.2. Developed e-learning system information model

Before developing own ELS model, the online learning models created by various scientists were analyzed. Anderson's Online Learning Model (Anderson, 2011) describes the DD as the combination of three main objects: student, teacher, and educational structured content delivered through a specialized software framework. Bosh (2016) proposed to transform Anderson's model into a Blending with Pedagogical Purpose Model, it expanded the mandatory actions, which ensure the effectiveness of DOL. Multimodal Model for Online Education by Picciano (2017) represents DD as a community with the following functions: e-content, social communication, independent study, dialectic, evaluation, student generated content, reflection.

The development of the ELS information model for DSTU was carried out on the basis of requirements and the blended-learning model mentioned above. In the process of developing the features and characteristics of Anderson's, Bosh's and Picciano's models were taken into account. The readiness and prospects of launching DOL at DSTU have been studied within the framework of the international project IRNET by conducting a survey for students and teachers (Yalova, Zavgorodnii, Romaniukha, & Sorokina, 2016). The proposed ELS model is presented graphically in Figure 2.



Figure 2. DSTU E-learning System Information Model Source: Own work.

The created ELS information model contains five components that ensure the organization of DOL for educational process participants, namely:

- 1. E-content is a component responsible for the creation, storage and distribution of the educational literature electronic version. During the existence of blend-ed learning at DSTU, the array of electronic educational literature was formed:
 - guidelines for practical, laboratory, coursework, independent, qualification work, students' internship;
 - lecture notes;
 - study guides and textbooks.

Access to the available ELS e-content to be provided through the appropriate links to resources posted on the university informational portal. The access mode is asynchronous. Viewing the contents of files is available after downloading them. Educational materials can be added in various formats: text, presentations and videos.

- 2. Discussion Board is a component that organises message exchange between all educational process participants, where a teacher can publish his general guide-lines, advice, and wishes. There are two modes of using the discussion board:
 - public correspondence for viewing by all authorized users;
 - personal correspondence for communication between a specific student and a teacher.

Discussion Board is the organization of feedback from the teacher.

- 3. Evaluation is a component that organises control and evaluation of the students' obtained knowledge. This component is organized in two forms:
 - checking/evaluating practical task;
 - testing. Tests are formed online through special forms.

It is possible for a teacher to create and send:

- a personal task to the selected student.
- a collective task for the student group

Ready-made tasks are sent by students in text, video or presentation format. For each student interacting with the teacher, a history of assignments is created, indicating the type of actions, date and time.

There are two modes for each test:

- control mode to receive a mark for its completion;
- learning mode to provide students' self-control.
- 4. Collaboration is a component that provides a platform for collective discussion on a certain problematic topic chosen by the teacher through a forum. The main difference with the Discussion Board component is that the questions/ answers and comments of the discussion participants are grouped by topic and are available only to authorized users identified by the teacher as the target audience.
- 5. Reflection is a component that provides the educational process participants with the reporting information. The ELS reporting information is formed on the basis of accumulated statistical data about: students' and teachers' activity; received intermediate and resulting grades.

Displaying student progress data is provided to:

- each teacher in the form of the Study Report Card for each group and discipline. Its graphical Ukrainian language web interface is shown in Figure 3;
- each student in their virtual dashboard;
- system administrators and university management, it contains statistical information about the daily, weekly, monthly activity of the educational process participants' interaction with the ELS and among themselves.

Програмування Інтернет 4 курс.										
шь	JS	API HTML-5	AJAX	XML	Повідомлень	Файлів	Тестування	Оцінка в балах	ECTS	Дата
Г.Ю.Є.	•	•	•	0	2	5	11	95	A	2020-05-01
Д.О.В.	•	•	0	0	2	2	5	85	В	2020-05-01
К.Ю.С.	•	0	•	0	1	1	2	70	D	2020-05-01
К.Д.О.	0	0	•	•	1	1	1	61	E	2020-05-01
М.В.Д.	•	0	0	•	0	2	1	70	D	2020-05-01
P.I.O.	•	0	•		0	2	2	61	E	2020-05-01
C.B.C.		•	•	•	0	0	0	40	FX	2020-05-01
C.A.B.	•	•	0	0	1	0	2	70	D	2020-05-21
C.€.O.		•	•		0	0	0	40	FX	2020-05-01
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Figure 3. Web Interface of the Study Report Card: Teacher's View

Source: Own work.

Table 1 presents a generalised specification of the ELS main functions and the valid users actions.

Table 1

User role	System function	Valid actions				
Administrator	Authorization	Gaining access to distributed functions and ELS data				
	System database administration	Creating a database backup copy Data recovery Supporting a trouble-free operation of the ELS database				
	Program code administration	Adding, replacing, removing, commenting, testing program code System software trouble-free operation support				
	Data operation	Data operation with database tables				
	Virtual dashboard	Forming requests input parameters Results data sampling obtaining Analysis of statistical data				
Teacher	Authorization	Gaining access to distributed functions and ELS data				
	Stored data modification	Adding, editing database data through the web interface Posting text, video files and presentations Removing previously posted own e-content				
	Collaboration	Moderation of public and personal messages in the				
and feedback		discussion board				
		Adding new forum topics, deleting, editing existing				
	Students	Posting general and personal tasks				
	evaluation	Downloading files received from students				
		Returning tasks after correction				
		Changing the status of the task progress Grading based on the results of completed tasks				
		Getting notifications about passing the tests				
		Putting down the resulting grades				
		Keeping Study Report Card				
	Virtual dashboard	Obtaining statistical information about students educational process progress				
Student	Authorization	Gaining access to distributed functions and ELS data				
	Independent study	Viewing, downloading, searching for e-content				
	Interaction with teacher	Sending messages, questions, comments Collaboration in the discussion of forum topics				
	E 1 (*	Participation in Discussion Board correspondence				
	Evaluation of obtained knowledge	Adding, sending completed tasks Passing tests in different modes				
	Virtual dashboard	Obtaining statistical information				

Valid actions and ELS users' roles functions

Source: Own work.

3. FEATURES OF SOFTWARE IMPLEMENTATION AND APPLICATION IN THE EDUCATIONAL PROCESS

On the basis of the developed ELS information model, its software implementation and application in the architecture of the existing university website and informational portal were organized. The principles of flexible Agile methodology for software development were used to develop the ELS. The process of software implementation had many features of extreme programming:

- constant adjustment of system requirements;
- frequent updating of software product versions;
- close interaction with end users;
- extremely short implementation timeframes;
- maximum release speed.

There are no possibilities to present all ELS web forms in the paper, nevertheless Figure 4 demonstrates some of them. A complete set of ELS web forms is available throw the link URL: https://www.dstu.dp.ua/uni/index.html#student.



Figure 4. E-learning System Web Interface: Ukrainian Language Source: Own work.

One of the main document regulating the educational process organization under quarantine conditions was the DSTU's Decree dated 01.04.2020, in which the developed ELS was put into operation. ELS application was established as an obligatory and integral part of the DOL organization, considering nationwide quarantine restrictions. In addition, a number of organizational and administrative measures related to the ELS implementation in the educational process were taken. The main organizational tasks included:

- implementation of a quick and comprehensive distribution of the ELS user manual and background information about the system;
- formation of user access log, which stores information about problems and errors that have arisen during the ELS use. Accumulated data was used to make changes to the ELS program code through program scripts injections;

The purpose of the administrative measures was to regulate the teachers work with the ELS, which included:

- amendments entering into the regulatory documents describing the educational process at DSTU;
- decree and directives creation regulating the place, role, tasks, functions, expected results, reporting forms, rights and obligations of DOL participants through the developed ELS.

Deans, heads of departments and curators of academic groups were entrusted to inform the students about the transition to DOL. All teachers and students of all education forms and specialties were involved in the DOL organization. Access to the ELS is provided via the Internet and various devices, the only requirement for the user's software is the browser availability.

CONCLUSION

The results research into the design, development and implementation of an ELS in the educational process at DSTU were presented in the paper. The proposed ELS is a non-commercial software application. Its main purpose is to ensure the effective acquisition of general and professional competencies by students of all specialties, during the transition from face-to-face to 100% DOL. At the time of quarantine restrictions announcement, a blended learning was applied at DSTU. The use of the developed ELS made it possible in the shortest possible time to organize a full-fledged DOL, with the implementation of functions: asynchronous communication, organization of collective interaction through the discussion board and forum, educational e-content sharing, learning outcomes evaluation, accumulation and processing of statistical data. Learning has been carried out online through the ELS web interface, that made it possible to complete the academic year successfully in accordance with the curricula of all university specialties. The assessment of the ELS use results and feedback from users allows to claim that the developed ELS adequately takes into account the incoming requirements.

Analysis of accumulated statistical data about students and teachers' activity, making a survey on satisfaction and expectations regarding the implemented ELS, specifications formation for the expansion and ELS functionality improvement are the topics of the further scientific work.

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