Cloud Resources and Services for Development of Self-Educational Competence of Future IT Specialists: Business Process Modelling and Examples of Using

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Abstract. The research is devoted to the scientific substantiation of building self-educational competence of future IT specialists using the cloud resources and services by applying the process approach. The application of the process approach to management and educational activities in higher education institutions, the structure of self-educational competence and the use cloud resources and services. Taking into account the requirements of the modern labor market, the specifics of training future IT specialists and the need to build their own self-educational competence, the structured analysis and design techniques model of self-educational competence of future IT specialists was developed. This model identifies the following processes: elaboration of the e-learning course (ELC) with integrated cloud resources and services for online learning, organization of the training activities in line with the mixed learning technology, organization of students' project activities, assessment of the level of development of the professional and self-educational competences of future IT specialists. Input and output data, managerial impacts and mechanisms, and resources for the implementation of the process are determined for each of the processes. The influence of the implementation of each process on the development of components of self-educational competence is substantiated. The level of self-education competence of future IT specialists is determined based on the proposed indicators. The results of the study confirm the effectiveness of the implementation of the proposed model of the system of development of self-educational competence in the future specialists in information technologies using the cloud resources and services.

Keywords: Cloud Resources, Cloud Services, Business Process Modelling, Self-educational Competence, Future IT Specialists.

1 Introduction

The modern stage of development of higher education is connected with the transition to the practical realization of a new educational paradigm aimed at creating a holistic system of continuous education and expanding the sphere of students' self-education under the conditions of active use of information and communication technologies (ICTs) [1], which make it possible to build and develop self-educational competence, self-organization skills and self-education of future specialists. It is not sufficient to build professional, research or communicative competences to train a highly skilled information technology specialist who is ready for professional activity under the conditions of the rapid development of the IT industry. The successful professional development of a future IT specialist re-quires the development of a self-educational competence as a basis for further self-improvement and competitiveness in the labor market in the context of intensive development of information technologies, which covers a wide range of cloud resources and services for the development of self-educational competences in the process of training future IT specialists.

The effectiveness of the self-educational competence development in IT students in the context of widespread use of information technologies, in particular, the cloud-based learning environment, mass open online courses (MOOCs), cloud resources and services for practical work, technology platforms, services for teamwork, etc. also depends on learning technologies. The application of blended, adaptive, and project-based learning technologies contributes to a qualitative development of professional and self-educational competences. In this regard, the development of a modern model for the development of professional and self-educational competences of future IT professionals capable of solving complex, practical-oriented tasks are necessary and relevant.

The purpose of the article is to identify and model business processes for learning using cloud services to develop self-educational competence for IT students.

2 Theoretical Background

The essence of the process approach in the management of the educational institution is that the emphasis in task setting and performance evaluation is transferred from the functional units and quality elements to business processes, that is, processes that create values for the consumer and educational institution [2]. The process approach in education is meant to regulate the educational process on the basis of assessing its condition according to specially defined quality criteria for all the components of the process itself, as well as the factors that influence the final result [3]. A. Graule, V. Azarov, M. Mizginova touch upon issues concerning process-service approach to e-learning design and business processes management [4].

Based on the analysis of theoretical and methodological principles of self-educational competence development in higher education, the content essence, the structure of self-educational competence of future IT specialists as a set of motivational-value, organizational-technological, practical-activity, reflexive-analytic components and the level of its development are determined [5], [6], [7]. The content of the notion of „self-educational competence of future IT specialists" will be understood as the confirmed ability of the individual to carry out self-educational activities to deepen the theoretical knowledge and improve practical skills in order to respond flexibly to the rapid changes in the modern information society and the ability to independently solve the professionally-orientated problems in the field of information technology with the aim of increasing the personal level of competitiveness in the labor market [7].

3 The Presentation of the Main Research and Explanation of Scientific Results

The questions and problems concerning the quality of educational services, training of specialists in conformity with modern requirements of the labor market and the availability of the necessary knowledge, skills and abilities are a priority task of the sphere of education. The quality of specialist training depends to a certain extent on the organization of the educational process, the competence of the academic staff of the institution of higher education (HEI), as well as on information and methodological support. The research of the process approach problems in the educational process, as well as the model of development of professional and self-educational competence of IT specialists, is presented in scientific works, however, there is a need to study complex issues of managing the process of self-educational competence development and implementation of its strategic planning.

3.1 Process Approach Model of the Self-Educational Competence

Improving the quality of training and development of self-educational competence of IT students is one of the main requirements at present, especially on the IT labor market. A process approach was chosen to build a model of the self-educational competence of future IT specialists. The process model of forming the self-educational competence of future IT specialists is considered as successive parallel sub processes of competences development within the organization of various stages of the educational process and the application of various teaching technologies.

Given the rapid changes in the modern information society and the need to continuously increase IT specialists' level of competitiveness in the labor market, it is necessary to determine the conditions under which the ability of future IT specialists for self-improvement and professional growth will be most effective.

The main advantages of the process approach while training IT students are the following:

- coordination of various process groups of the organization of students' educational and project activities;
- improvement of the effectiveness and efficiency of the organization of the educational process;
- result-orientated process, which means the commitment to the increase of the students' professional and self-educational competences level;

– increase in the predictability of the results;
– identification of opportunities for purposeful improvement of processes.

Principles of the process approach are the manifestation of flexibility and continuous control, when all the activities of the enterprise are considered as a network of interconnected and interrelated business processes and their subsequent management in accordance with the PDCA cycle (Plan-Do-Check-Act). In the standards of ISO 9000 series, the PDCA cycle is described as follows [8]:

– Plan: process planning (accounting for input data that initiate the process; operational definition of decomposed goals and tasks for executors based on the objectives of the process; operational distribution of responsibilities and powers; definition of „control points" for ongoing verification; risk assessment for the quality of the process; determination of indicators, criteria and methods for evaluating and monitoring the effectiveness of the process, others);
– Do: execution of the process (an algorithm for implementing all stages and operations with the detail and form determined for the required process, measures to ensure the stability of the process and compliance with the scheduled parameters, guidance on the application of necessary documents, records, etc.);
– Check: evaluation and analysis of the effectiveness of the process (description of the actions for data registration according to the determined parameters of the process effectiveness, comparison with established criteria, trends identification, identification of inconsistencies that occurred, as well as potential inconsistencies, the development of reporting protocols, etc.);
– Act: initiating and implementing actions to improve and enhance the process (description of actions with analysis of causes of non-conformities, development and implementation of corrective and/or various precautionary measures).

The inputs and outputs of processes, their sequence and interaction can be described by a process model, which reflects all activities of the organization of the educational process at the HEI. Under the process, we will understand the totality of interconnected and interacting activities aimed at converting inputs into outputs. The scheme of the process approach implementation is presented in fig. 1.

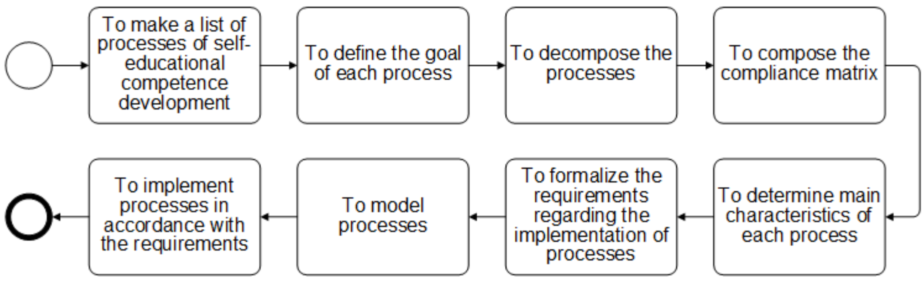

Fig. 1. The scheme of implementing the process approach to the development of self-educational competence

To reach the set goals, a model of the process of the development of future IT specialists' self-educational competence using cloud resource and services was developed, which is graphically presented in fig. 2.

The model construction of the process of the self-educational competence development involves preliminary selection of its main groups of processes, namely: the preparation of ELCs containing integrated cloud-based academic resources and services (1), the organization of student learning activities based on blended and flipped learning technologies (2) and project activities of students using the services for team management (3), the definition and analysis of the levels of development of professional and self-educational competence of future IT specialists (4).

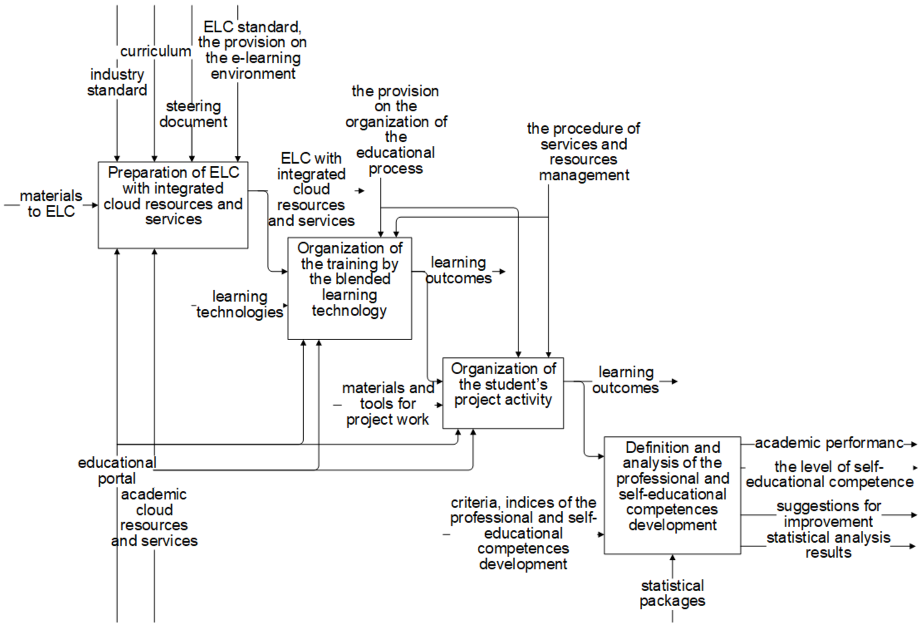

Fig. 2. Decomposition of the context diagram in the IDEFO standard (SADT methodology)

3.2 Process 1. Integration of Cloud-Based Academic Resources and Services into ELC

The purpose of the process is to develop an ELC with integrated cloud resources and services for the professionally-oriented academic disciplines.

The regulatory framework, based on which future IT specialists are trained, can be subdivided into relevant industry standards, approved in the subject area 12 „Information Technologies", corresponding curricula for training future IT specialists and steering documents for academic disciplines according to the curriculum. These normative documents determine the preconditions for access to learning, the orientation and main focus of the program, the amount of ECTS credits necessary for obtaining a bachelor's or master's degree, a list of general and special (professional) competences, normative and optional content of specialist training, formulated in terms of learning outcomes and requirements for quality control of higher education.

With the fast-growing Massive Open Online Courses (MOOC) community and the increase in the number of Learning Management Systems (LMSs) available online, the amount of shared information is massive. Current LMS – in particular, MOOC providers – offer many advanced content delivery techniques: interactive video, active retrieval practices, and quizzes to enhance the pedagogical process [9]. The success of MOOCs (Massive Open Online Courses) is not limited only to their openness to all heterogeneous learners, but also in their integration into the curricula of initial training in higher educational institutions [10]. MOOCs support many forms of instruction, including video lectures, reading with conceptual questions, discussion boards, and various forms of learning-by-doing with automated or peer feedback [11].

The model of system *S* can be presented as a set of values, which describe the process of its functioning and in the general case form such subsets:

- the totality of input data of the system: $x_i \in X, i = \overline{1, n_X}$;
- the totality of mechanisms and tools impact on the system: $m_k \in M, i = \overline{1, n_M}$;
- the totality of managerial impact on the system: $u_j \in U, i = \overline{1, n_U}$.

Herewith, in the listed subsets we distinguish controllable and uncontrollable variables. In the general case X_i, M_k, U_j are the elements of non-intersecting subsets containing both deterministic and stochastic components. In modeling system S, input data, mechanisms and tools impact and managerial impact on the system are independent (exogenous) variables, which in vector form are, respectively, presented as follows:

$Y_{ni}(t) = A_n(x_{n1}, \dots x_{ni}, m_{n1}, \dots m_{nk}, u_{n1}, \dots u_{nj})$, where t – time.

Input data: X_1 – materials for ELC, where $X_{1.1}$ – a list of competences to be formed in the students within the academic discipline; $X_{1.2}$ – academic resources and services; $X_{1.3}$ – criteria for selecting academic resources and services; $X_{1.4}$ – theoretical course materials; $X_{1.5}$ – course lab sessions; $X_{1.6}$ – assignments for independent work; $X_{1.7}$ – consolidating assignments of the course.

Management: $M_{1.1}$ – industry standard; $M_{1.2}$ – curriculum; $M_{1.3}$ – steering documents; $M_{1.4}$ – ELC structure standard; $M_{1.5}$ – the provision on the e-learning environment.

Mechanisms and tools: $U_{1.1}$ – CLMS; $U_{1.2}$ – cloud resources; $U_{1.3}$ – cloud services.

Decomposition of A_1 process: $A_{1.1}$ – analysis and selection of cloud resources, services; $A_{1.2}$ – supplementing the theoretical material and tasks for the independent work with ELC cloud academic resources; $A_{1.3}$ – arranging lab sessions and consolidation classes with the use of selected cloud services.

Output data: Y_1 – ELC with integrated services and resources, where $Y_{1.1}$ – theoretical materials of ELC with integrated cloud services and resources; $Y_{1.2}$ – lab sessions with integrated cloud services; $Y_{1.3}$ – tasks for the independent work with integrated cloud resources and services; $Y_{1.4}$ – consolidation classes with integrated cloud services.

For the description of the process execution scenario, a Business Process Modelling Notation (BPMN) was selected. The sequence and logic of the actions performed by the participants of the process of integration of cloud resources and services in the ELC is demonstrated in fig. 3.

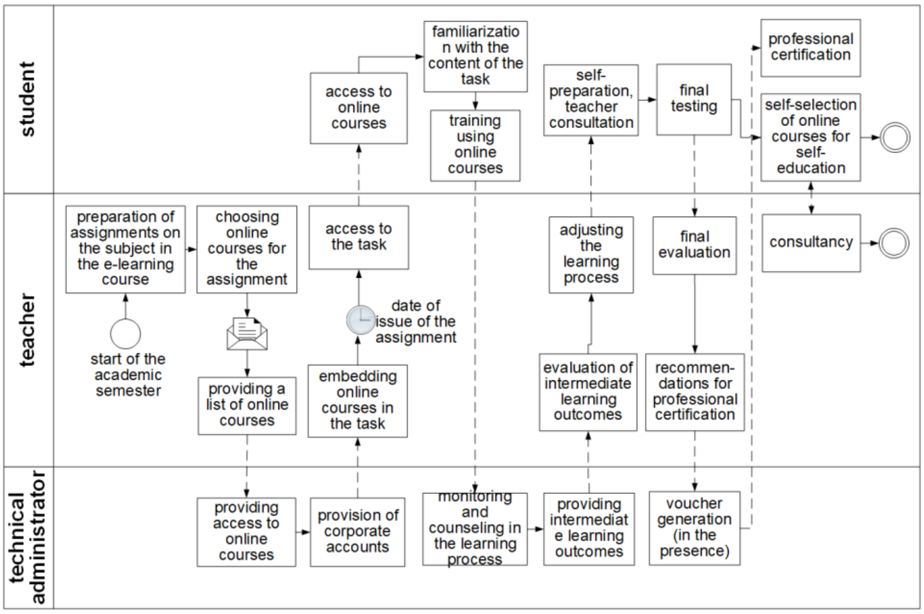

Fig. 3. BPMN for process of the integration cloud-based academic resources and services into ELC

Preparation of ELC resources containing integrated cloud resources and services will expand the opportunities for students to independently study the learning materials developed by leading technology companies. Such resources are constantly updated in line with changes in technology, which gives an opportunity to get the latest materials for self-education. This creates a pool of resources and services within one ELC to study one discipline. When mastering the educational material, performing practical tasks, reflecting on the use of these resources and services, students understand the need for self-education, which motivates them to master the new material.

For training IT specialists, it is advisable to use the academic resources of leading IT companies such as Microsoft Imagine Academy, Microsoft Virtual Academy, Cisco Networking Academy, IBM Academic Initiative, and various online technology platforms (MOOCs) such as Khan Academy, edX, Coursera, Prometheus et al. This allows students to complete their studies under „computer science" with the subsequent award of the corresponding certificate. This will allow them to obtain the necessary knowledge in the field of information technology, which they can easily apply in practice during their professional activities in the future. An example of tasks for independent work with integration course „BPMN 2.0 with Brian: A Beginner's Guide" Udemy is shown in fig. 4.

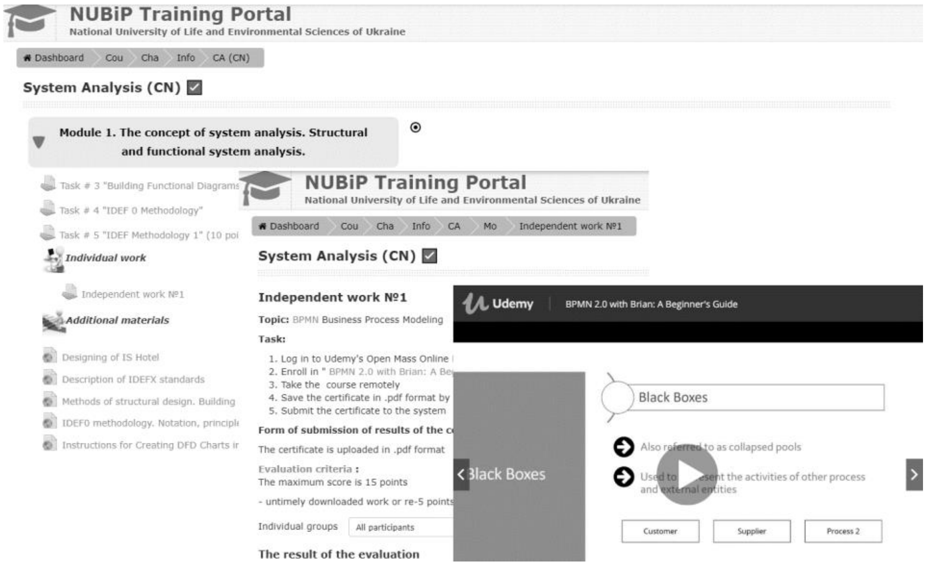

Fig. 4. A sample task with integrated resource massive online courses Udemy

For setting practical tasks, laboratory and group activities, such cloud services should be selected for project work on the task: platforms, software, software environments.

3.3 Process 2. Blended Learning Using Integrated Cloud Resources And Services into ELC

The purpose of the process is to effectively organize student learning activities in studying theoretical material and acquiring practical skills and abilities.

Organizational flipped classroom where students view screencasts, read textbook material and take an on-line quiz before class has been implemented in a process dynamics and control course. The class periods involve brief lectures summarizing what they have learned, and include discussions and advanced problem solving using MATLAB [12]. Examples of the implementation of flipped learning in the Ukrainian and Polish Universities in the process of teaching disciplines of the Information Technology cycle or during introduction to the module „Information technology” are presented in the following works [13]. Blended learning technology integrates the traditional learning tools with the tools of new information technologies [14]. Integrating the information and methodological support with the blended learning technologies is pedagogically appropriate and encourages optimizing the learning process and its computerization [15].

For organizing blended and flipped learning in order to form self-educational competence, we should develop a program of blending different types of student activity in accordance with the stated tasks: online training, individual, group training under the guidance of a teacher, cooperative learning.

Input data: X_2 – learning technologies, where $X_{2.1}$ – educational materials and activities of the ELC; $X_{2.2}$ – a blended learning program; $X_{2.3}$ – a flipped learning program; $X_{2.4}$ – assessment criteria (scale).

Management: $M_{1.1}$ – the provision on the organization of the educational process; $M_{1.2}$ – services and resources management procedure.

Mechanisms and tools: $U_{1.1}$ – CLMS; $U_{1.2}$ – cloud resources; $U_{1.3}$ – cloud services.

Decomposition of A_2 process: $A_{2.1}$ – organization of blended learning; $A_{2.2}$ – organization of flipped learning; $A_{2.3}$ – assessment and analysis of learning outcomes.

Output data: Y_1 – learning outcomes, where $Y_{2.1}$ – completed tasks for lab sessions; $Y_{2.2}$ – certificates of using cloud resources; $Y_{2.3}$ – completed tasks for independent work; $Y_{2.4}$ – control assessment (score); $Y_{2.5}$ – results of students' reflection.

Teachers, students and technical administrators are participants in this process. A model of the process of blended learning using integrated cloud resources and services in the ELC is presented in fig. 5.

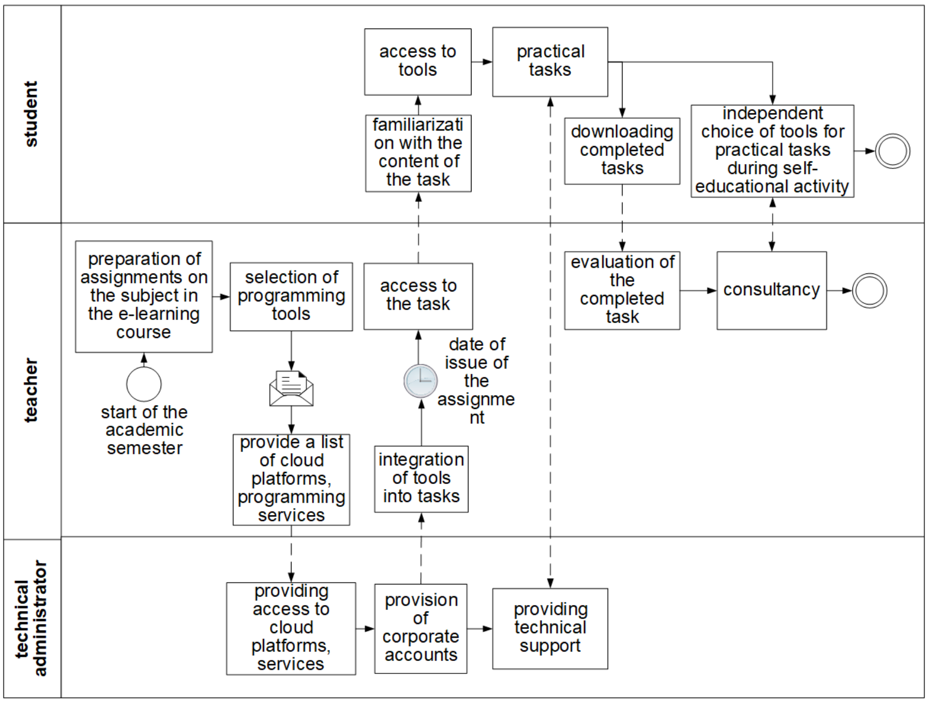

Fig. 5. BPMN for blended learning process with using integrated cloud resources and services in the ELC

An example of organizing learning activities for student blended learning technology using cloud platform Microsoft Azure is shown in fig. 6.

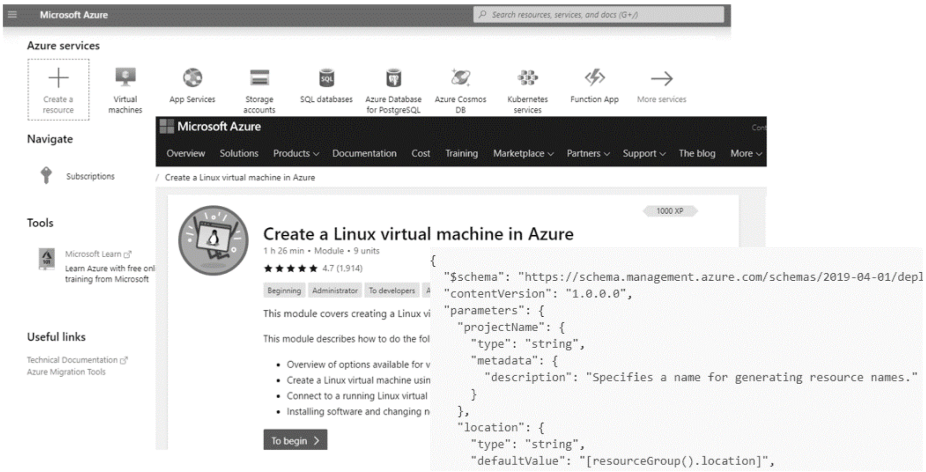

Fig. 6. Example of using the cloud platform Microsoft Azure

As a result of this process, students improve the skills of an independent organization of study material, completion of practical tasks with the aid of recommended resources and services, develop soft skills, aimed at the proper time management of completing tasks, the organization of communication with the teacher and students, the organization of personal learning environment, information management and personal knowledge.

3.4 Process 3. Students' Project Activities Using the Services for Team Management

The purpose of the process is to organize professionally-oriented team projects, which will increase students' motivation for self-education and promote the development of both professional and personal skills.

As one of the general competences of future IT specialists is the ability to work in a team, it is recommended to use the project methodology while training future IT specialists. Various task and project management software tools are employed to support team collaboration, for example, tools for knowledge management, information exchange, communication, shared authoring and collaborative work [16]. The use of SharePoint for designing an e-environment for the project implementation in the field of study contributes to the students' motivation to learn and develop both hard skills and soft skills [17], [18], [19].

Teamwork on project implementation is quite effective and productive, as it allows solving complex and cumbersome tasks that cannot be performed on time and effectively alone, even by highly skilled professionals.

Input data: X_3 – materials for the project activity, where $X_{3.1}$ – tasks; $X_{3.2}$ – performance plan; $X_{3.3}$ – services for team work; $X_{3.4}$ – services selection criteria; $X_{3.5}$ – comments in the process; $X_{3.6}$ – assessment criteria.

Management: $M_{1.1}$ – the provision on the organization of the educational process; $M_{1.2}$ – services and resources management procedure.

Mechanisms and tools: $U_{1.1}$ – CLMS; $U_{1.2}$ – cloud resources; $U_{1.3}$ – cloud services.

Decomposition of A_3 process: $A_{3.1}$ – task setting, selection of the service for team work; $A_{3.2}$ – monitoring of the project implementation; $A_{3.3}$ – results presentation; $A_{3.4}$ – results assessment.

Output data: Y_1 – learning outcomes, where $Y_{3.1}$ – completed project; $Y_{3.2}$ – mark (score); $Y_{3.3}$ – reflection results.

Business process model of the students' project activities using the services for team management is shown in fig. 7.

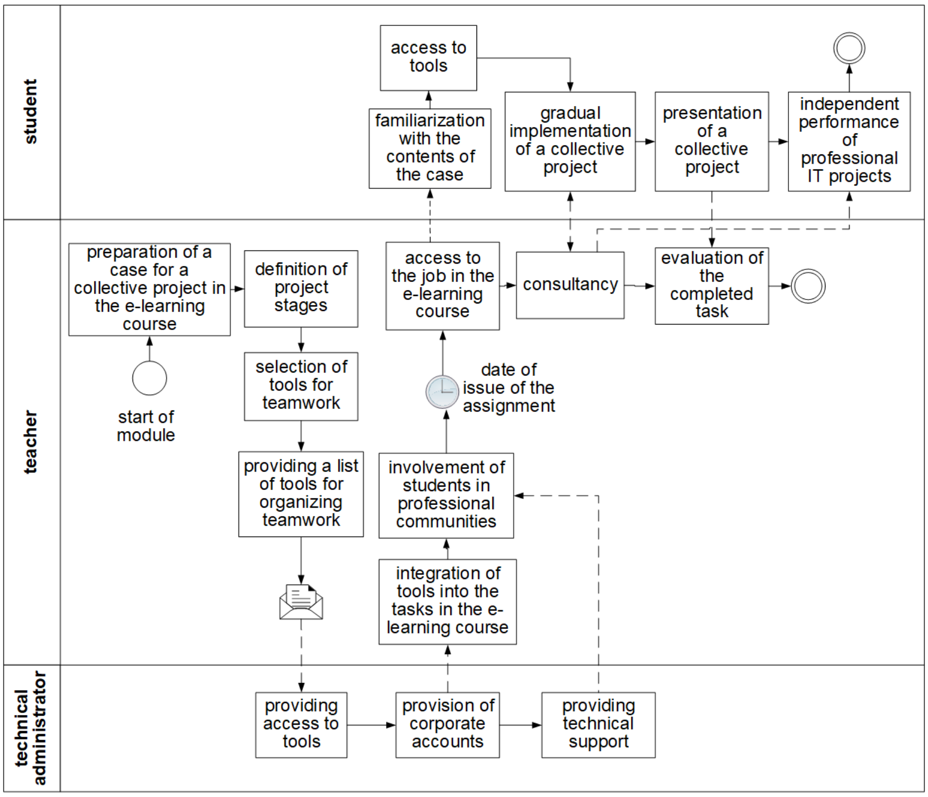

Fig. 7. BPMN for process of the students' project activities using the services for team management

This process makes it possible to form in the students not only a professional integral competence, as in the process of project work a complex systemic problem is solved, which involves the professional competences formed as a result of studying various disciplines. The need to carry out part of the project independently and in collaboration develops students' self-educational competence and a set of cognitive, communicative and organizational soft skills. An example of organizing a team of professional projects using a cloud service to manage the Microsoft Teams team is shown in fig. 8.

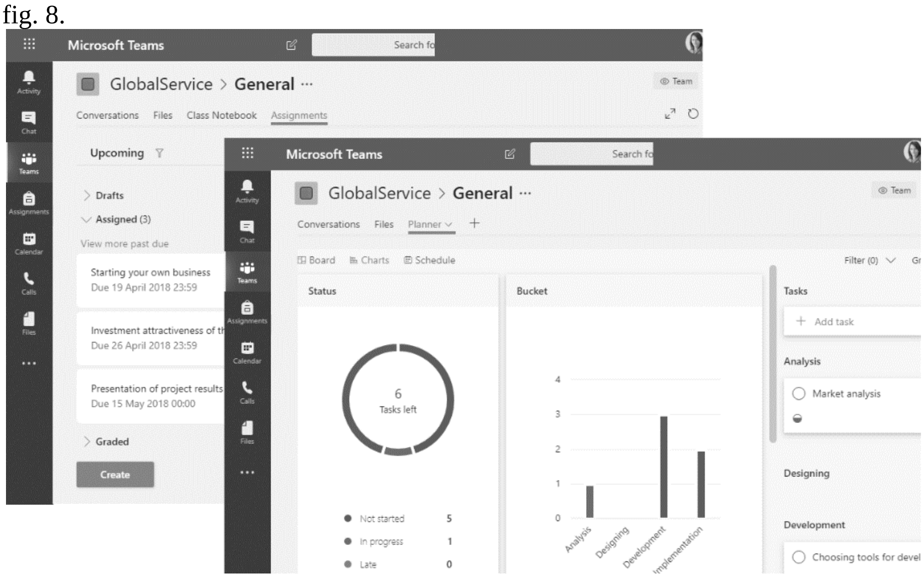

Fig. 8. Example of cloud service Microsoft Teams in the group project work

3.5 Process 4. The Definition and Analysis of the Levels of Development of Professional and Self-Educational Competence of Future IT Specialists

The purpose of the process is to analyze the effectiveness of using cloud-based academic resources and services for the development of self-educational competence.

The level of development of professional competence is determined using competently oriented tasks and surveys – in accordance with the requirements of the industry standard. The level of self-educational competence is determined on the basis of indicators (indices), which are determined in accordance with the component structure of self-educational competence [7].

Input data: X_4 – levels of professional and self-educational competence, where $X_{4.1}$ – the mark for the educational activity; $X_{4.2}$ – the mark for the project activity; $X_{4.3}$ – reflection results; $X_{4.4}$ – indicators (indices) of self-educational competence development; $X_{4.5}$ – statistical analysis methods.

Management: $M_{1.1}$ – the provision on the organization of the educational process.

Mechanisms and tools: $U_{1.1}$ – statistical packages.

Decomposition of A_4 process: $A_{4.1}$ – defining the assessment criteria; $A_{4.2}$ – defining the criteria and indices of the professional and self-educational competences development; $A_{4.3}$ – assessment of academic performance; $A_{4.4}$ – defining the level of self-educational competence.

Output data: $Y_{4.1}$ – academic performance, where $Y_{4.2}$ – the level of self-educational competence; $Y_{4.3}$ – results of statistical analysis (absolute academic performance, quality, progress in the development of professional and self-educational competence); $Y_{4.4}$

– suggestions on the improvement of the processes of self-educational competence development.

In order to improve the process of self-educational competence development, it is necessary to obtain the results of its development according to different indicators and to make a decision on changing the forms, methods and tools for forming the corresponding components.

4 Results of Research

Experimental verification of the effectiveness of the educational process organization in accordance with the developed model was carried out taking into account the processes decomposition and the following functions: integration of Microsoft Imagine Academy, Cisco Networking Academy, IBM Academic Initiative, Prometheus academic resources into ELC; the use of cloud services and resources for laboratory classes, tests and practical tasks: programming environments, database management, virtual simulation laboratories, data processing and analysis platforms, and more; the use of cloud services and resources for the organization of the project work: Microsoft Office 365, G Suite, Jira etc.

The level of self-educational competence development of the IT-faculty students was assessed by the following indicators:

- motivation to mastering new educational materials; the ability to make an independent choice of online resources to continue their own self-development in the chosen direction; to build and adjust their own self-learning trajectory by regulating and controlling the time of training in additional online courses; to form an adequate self-assessment of their achievements; the ability to pass professional certification;
- ability to independently choose the best way to achieve the goal, to determine the sequence and duration of its stages, to select the tools and services to complete the task;
- ability to search, analyze and collect the necessary information, plan activities, establish communication and team collaboration, facilitate the increase in students' motivation for self-education, development of both professional and personal skills.

The characteristics of the levels are developed for each indicator: low, middle, high [7]. Research methods for each process include observation, testing, diagnostics of levels of self-education competence development, evaluation of laboratory and independent work, monitoring of the development of self-education and professional competence, evaluation of educational projects, questionnaires, reflection.

The control group adhered to traditional teaching technologies without the use of cloud services and resources.

For statistical verification of the obtained results, the null hypothesis is formulated: the use of cloud resources and services does not affect the level of self-educational competence of future IT specialists. That is, the existing changes in the levels of self-education competence are random. Frequency tables (conjunction tables), criterion $\chi 2$ and one-way ANOVA were used for this purpose. The calculated Pearson criterion value (for significance level 0.05 and 6 degrees of freedom) is greater than the critical value: 40.021> 12.592. Therefore, we accept the alternative hypothesis: the use of cloud resources and services influences the level of self-education competence of students of IT profession.

The comparison of the level of self-educational competence in experimental and control group of students regarding the implementation of the process approach is presented below (fig. 9).

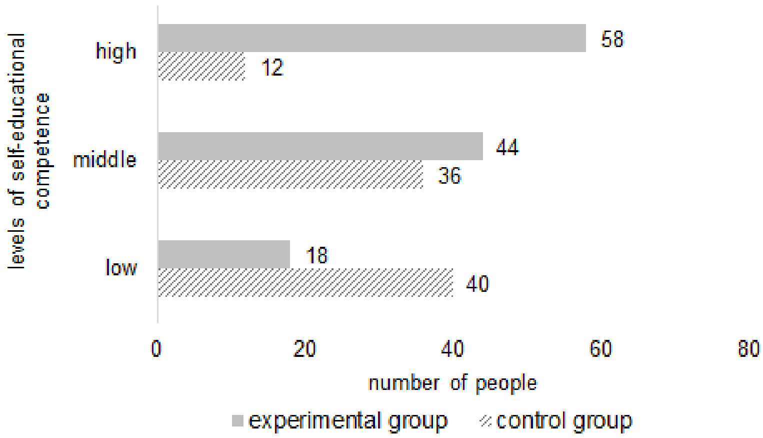

Fig. 9. The comparison of the level of self-educational competence development in experimental and control groups (the total number of participants in the experiment is 208 people)

Thus, the level of development of self-educational competence in the control and experimental groups differs. We see that the number of students with high levels of self-education has increased by 34%. The number of students with an average level of self-education competence decreased by 4%, with a low level - by 30%.

Evaluation of results of the presented model of the process approach to the development of self-educational competence of future IT specialists using the cloud services and resources proved the expediency of its application, as evidenced by the results of diagnosing the levels of self-educational competence of future IT specialists.

5 Conclusions

The process approach to the self-educational competence development in the future IT specialists makes it possible to clearly identify the interrelations between processes and the necessary resources to ensure their implementation. This approach contributes to improving the organization of the educational process with the aim of increasing students’ level of competence by activating integrated team training, organizing project activities, developing students’ motivation to self-education, which ultimately results in an increase in the level of students’ progress in professionally-oriented academic disciplines as well as in a more effective use of cloud resources and services. The decomposition of the processes of self-educational competence development of the future IT specialists enables the academic staff to obtain an integrated technology for the implementation and monitoring of the increase in the level of the development of students' self-educational competence.

Further research may focus on developing resources for students to work independently in accordance with their dominant teaching styles and researching new factors that influence the development of self-educational competence of future IT professionals.

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