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CLOUD TECHNOLOGIES IN LEARNING: ONTOLOGICAL APPROACH

Abstract. The article considers an ontological approach to the creation and use of learning information systems and learning process management systems that operate in a cloud environment. The proposed ontological approach provides an opportunity to implement learning processes, supporting the sharing of both users (students, teachers, methodologists, etc.) and different training courses of common learning content stored in the cloud. The result of using cloud technologies and ontologies is the ability to make the necessary adjustments to the set of goals and objectives of the learning process, the learning process, the course, the requirements for the level of knowledge and competence of students. An ontological approach to building learning systems operating in a cloud environment is proposed. It is advisable to use the developed ontological model when implementing learning system in managing learning processes in higher educational institutions. The constructed ontological model provides an opportunity to implement continuous improvement of learning processes, supporting the sharing by both users (students, teachers, methodologists, etc.) and different training courses of common training content stored in the cloud. The result of using cloud technologies and ontologies is the possibility of making the necessary adjustments to the set of goals and objectives of the learning process, to the learning process, the training course, to the requirements for the level and competencies of trainees on the part of employers and / or the state. The developed ontological model of learning processes allows, using cloud technologies, to form a space of learning content. Sharing learning content across learning systems has not only enabled the use of ready-made, high-quality learning materials developed by the best teachers, but also reduced the time and resources spent on transferring content from one system to another. The proposed approach uses the integration of technologies such as: ontological modeling, intellectualization and informatization, as well as cloud technologies. The use of these technologies makes it possible to predict the occurrence of emergency situations in the learning process.

Keywords: ontological model; learning process; cloud technology; information technology; learning content; learning information system; learning management system

INTRODUCTION

The term "Cloud Computing" has been used to explain the placement and processing of information located on many servers - the "cloud" of the Internet. That's why there is a need to systematize the basic concepts, highlight the main features of the representation of information processes in the "cloud" and determine the place of "cloud" solutions used in the learning process.

Today, concepts such as: cloud operating system (OS), cloud computing, cloud technology, cloud computing, cloud systems are widely used. Cloud OS or Web OS is a software product based on the cloud computing paradigm and operating in a Web browser environment. This product is a client-server education with a Web interface that provides users (students, teachers, methodologists, education managers, etc.) with the ability to access educational and methodological information from any active point, for example, from a mobile device. Cloud operating systems appeared, in particular: eyeOS and Cloudo; Glide OS, Zero PC, AstraNOS Joli OS, Silve OS [1].

Cloud computing in education is a distributed data processing process in which computer resources (training courses, methodological information, tests, reference, auxiliary, accounting, control, organizational information, etc.) and network capacities are provided to the user in the form of an Internet service.

A feature of cloud representations is that information processes are implemented using Web service Internet. The most actively used services are: SOAP (Simple Object Access Protocol); REST (Representational State Transfer). These services provide: provision of services for any application; interaction of heterogeneous applications regardless of the time of their deployment, programming language and OS used; provision of services of one company for another, data exchange and remote procedure call; integration with any existing systems [2].

Microsoft announced the creation of a whole group of cloud technologies and software development [3], [4]: Windows Azure operating system; relational database management system SQL Azure; Windows Azure Platform AppFabric to connect traditional and cloud applications and secure data in transit. Windows Azure OS contains several interconnected modules: Compute Service, Storage Service and Fabric.

Compute Service is aimed at computing-related processes. A feature of its work is support for: multi-user mode (on several virtual machines), several copies of the same code on different servers. In this case, a cloud application can support one of two versions:

– The *Web version* (web role) runs an Internet Information Services (IIS) server on a virtual machine and processes HTTP- or HTTPS-requests. At the same time, versioning is possible in any programming language using any .NET technology that works with IIS (for example, ASP).

– The *Worker version* runs tasks in the background and does not run IIS.

Storage Service provides the following methods of working with data (including educational and methodological information): "binary" – for storing audio and video data; "table" – with the placement of data on several computers; "binding" – type "queue" FIFO (First Input First Output) for linking the "web-role" version with the "worker-role" version by writing requests to the queue with their subsequent fetching and execution, as well as passing the result through the "queue".

Fabric is used as a Fabric controller with many functions that ensure the selection of virtual servers to distribute them between *Web* and *Worker* roles and host Windows Azure applications on them, as well as the optimal choice of one of them to run the application.

The SQL Azure database management system stores educational and methodological information in the database of the higher educational institution (HEI), and on the servers of the cloud environment with active interaction with all Windows Azure applications.

In the field of learning process management, research based on the ontological approach is relevant [17], [18]. The rules for the interaction of learning processes and/or information resources in learning systems (and/or learning management systems (LMS)) are built on the basis of set theory, which makes it possible to develop a formal model. The purpose of this work is to form an ontological model of learning system (and/or LMS), the functioning of which is supported by cloud technologies.

The proposed ontological approach will make it possible to describe learning processes, supporting the sharing of learning content, and to control the assimilation of educational material, taking into the account the competencies embedded in the training (educational) programs for students in the field of knowledge "Information Technology" and "Computer Science"

CLOUD SERVICES IN EDUCATION

The main goal of the development and implementation of education is to provide quality education to the user (students, cadets, course participants, etc.), as well as employees of enterprises and organizations in a continuous production process.

To improve learning processes at all stages of the life cycle of an educational program, it is advisable to use learning systems (and/or LMS) to monitor and analyze the competencies acquired by users in a particular learning process, both on the part of HEIs and on the part of the state and/or interested enterprises - potential employers. The introduction of modern information technologies (IT) in the learning process allows you to achieve results only if the entire IT infrastructure is reliable and secure. It has high requirements:

– increase in productivity and reliability with an increase in the volume of processed information;
– reducing the cost of support and development;
– increasing adaptability to the needs of HEIs in IT-resources.

These requirements can be effectively met by using and developing IT for learning based on cloud computing, which is one of the most promising innovative areas for the development of service IT.

Cloud Services – goods, services and solutions for users that are supplied and consumed in real time via the Internet. *Cloud Computing* is a new model for developing, deploying and delivering cloud services. There are such types of the cloud computing [5]:

– IaaS – Infrastructure as a Service;
– PaaS – Platform as a Service;
– SaaS – Software as a Service.

There are Public Cloud, Private Cloud, Hybrid Cloud. Public Cloud implies the deployment of an infrastructure with the necessary software and mechanisms for accessing them outside the HEI-infrastructure – directly on the Internet.

Private Cloud is created on the basis of its own IT infrastructure to optimize its use within the framework of HEI.

The concept of cloud computing combines such models and technologies: Computing On Demand, resource computing model (Utility Computing), Grid computing, and providing various elements of an information system as a service.

The use of cloud computing has, in particular, the following advantages:

– possibility of using inexpensive computers by users;
– reducing costs and increasing the efficiency of the IT-infrastructure (transition to cloud services will reduce the cost of software, hardware and its maintenance by up to 50%; increase the flexibility and adaptability of the IT-infrastructure);
– possibility to rent software by the hour;
– increase in available computing power, software and the amount of data stored and used;
– measurability of resources and volume of work of users in a cloud.

The disadvantages of cloud computing, in particular, include:

– reducing the control of IT-infrastructure in the case of a public cloud;
– the need for a permanent connection to the Internet;
– limitation of the functional properties of software on the Internet compared to local counterparts;
– absence of domestic providers of cloud services (Amazon, Goggle, Saleforce are concentrated in the USA);
– underdevelopment of the domestic system of cloud computing.

Despite the advantages of cloud computing, domestic HEIs are wary of renting abstract, virtual facilities, preferring to work with specific, preferably their own, hardware and software.

An analysis of the market for learning systems and LMS demonstrates progress in promoting systems in the form of cloud (SaaS) services, which raises the level of their competition in the market, changing the course of development of the entire IT-industry and education.

IT-industry leaders create software products that meet market requirements and have a high level of sales. Some companies in this group (for example, Oracle) offer solutions at the level of Computing On Demand. Many software companies are investing in leading-edge technologies that will enable VDOs to gain faster access to improved management and security.

Most companies in this group offer, in particular, solutions based on SaaS services.

Some companies in the IT industry are focused on the market of university systems (training and management) and demonstrate higher efficiency on them. SaaS solutions are also present here.

FORMATION OF EDUCATIONAL PROGRAMS BASED ON ONTOLOGIES AND COMPETENCE-BASED APPROACH

The development processes of all forms of education cause changes in the field of higher education aimed at meeting the requirements of a competency-based approach in the formation of educational programs [6].

One of the main factors influencing the process of improving the quality of education is the development trend of the IT industry, defined as the mutual reinforcement of the following interdependent trends: social interaction, mobility, cloud technologies, process modeling (in economics, science and education) and information.

The development of modern IT and communications is characterized by a growing number of mobile devices connected to the Internet, as well as a variety of household appliances, home systems and sensors, called the Internet of Things. The growth in the volume of data generated by various devices requires access to common network computing resources to provide cloud computing (Cloud Computing), including using Big Data technologies [7].

The problem of processing structured and unstructured data leads to the complexity (sometimes even the impossibility) of the prompt introduction of semester adjustments to the programs of academic disciplines and curricula.

This situation is complicated by the expansion of the internal "filling" of the technological basis of learning content, based on complex, in particular, such technologies as: Web-technologies, cloud, multimedia, network, mobile, telecommunications, information security, artificial intelligence, etc.

To solve this problem, it is necessary to build specialized knowledge bases that use a variety of information resources on a specific educational topic related to the structure of the discipline and the requirements for the competencies of specialists. In the IT-field, the most active organizations that expand the boundaries of the space of knowledge and competencies in this subject area (SA) are: Association for Computing Machinery and the Institute of Electrical and Electronics Engineers [8], [9].

According to their classification of areas of study, the following main areas of study were identified: Computer Science - Computer Science, Computer Engineering - Computer Engineering, Software Engineering - Software Engineering, Information Systems - Information Systems, Information Technology - Information Technology. These areas combine training courses with the aim of acquiring appropriate competencies in the field of computing for students. The development of computer science required the introduction of new areas of knowledge into the knowledge space: “Information Assurance and Security”, “Networking and Communication”, “Platform-Based Development”, “Parallel and Distributed Computing”, “Software Development Fundamentals”, “Systems Fundamentals”.

In the Information Technology Competency Model [10], the competencies include the knowledge, skills, and abilities needed by specialists in the field of computing and new IT.

The approach to solving the complex problem of taking into the account the interaction and influence of connections between different levels of competence of IT-specialists involves the following sequence of steps: conceptualization; planning; data collection; data analysis and creation of a catalog of competencies; development of an educational program based on competencies and development of applications and pilot tests.

To identify the links between the components of the educational space, an ontology-based approach [17] is proposed, the use of which to build a logical model of knowledge representation allows you to holistically represent the IT-sphere and provide a common understanding of the terms and concepts in academic disciplines, organize and formalize the existing knowledge, implement the functions reference and teaching tool.

For the ontological analysis of descriptors that characterize the competencies of the field of knowledge "Information Technology", you need to do the following:

1. Construction of OWL-ontologies of the chosen SA using Protégé [11].
2. Compilation of a set of rules in the format of the SWRL (Semantic Web Rule Language) [12] rules included in the ontology file of the problem domain.
3. Development of system for the semantic analysis of descriptors, which implements an algorithm for ontological modeling of the representation of knowledge about the fields of knowledge "Information Technology" and “Computer Science”. The system component that provides access to the ontology and its processing forms an environment for working with data in the RDF, RDFS, OWL formats and supports the formation of queries to the ontology in the SPARQL language [13].

The inference process of an expert conclusion Values about the user's competence, presented as a set of learning outcomes for the relevant descriptors: skills, knowledge, skills and abilities, is carried out through a choice that satisfies the conditions of the SWRL rule included in the OWL-ontology. The input data entering the system of ontological analysis are unified by means of transformation to the form of RDF triples.

The input data of LMS, in particular, are:

1. Description of competence in the form of a set of descriptor values. The results are stored as RDF triples (for example, "Descriptor" + "View" + "Content").
2. The main characteristics of the descriptors of the competencies under consideration.
3. OWL-ontologies, including a description of the subject area, and a set of SWRL-rules for the logical derivation of recommendations on the correspondence of the educational profile and competences of specialists at the national and global levels.

The concepts of "knowledge" and "skills" are used to define the concepts of "learning outcomes" and "competence" in the above ontology scheme reflect the simultaneous presentation of skills, abilities and knowledge, both as competency descriptors and as learning outcomes. The organization of links between the main classes of the ontology is carried out through associative relations, which make it possible to understand the nature of the relationship between the concepts that describe the ontology classes and the entities of the educational space in the real life.

In addition to associative relations, when developing an ontology of competencies in the field of knowledge "Information Technology", relations of the "part – whole" type were used to determine the relationship of subclasses with their parent classes.

SHARING LEARNING CONTENT

The main problem with using learning systems (and/or LMS) is the difficulty of sharing learning content. Systems of different developers differ in the requirements for organizing and storing teaching materials, tests, progress reports, etc. For example, tests created in one system may require additional time, money, etc. to be used in another system. The unification of the created learning content that is used in training systems (and / or LMS) developed using cloud technologies is carried out in accordance with a certain standard.

This leads to the creation of conditions for the integration of interaction mechanisms between the components of educational systems (and / or LMS), users (students, teachers, methodologists, etc.) and external systems. Standards for learning systems (and/or LMS) include:

– AICC (Airline Industry CBT (Computer Based Training) Committee), which is based on the exchange of text files, but does not fully reflect the capabilities of Internet technologies.

– IMS (Instructional Management Systems), which combined the achievements of developments in distance education and specified them in XML-format.

– SCORM (Sharable Content Object Reference Model), which is developed on the basis of IMS for training using network technologies [14].

– Tin Can API – development of the SCORM standard (using the Tin Can API allows you to: account for the types of learning activities, such as: mobile learning, games, simulations, informal learning, students' actions in the real world; event tracking without Internet connection; improved security and authentication) [15].

Most learning content is created in accordance with SCORM, so its use in training systems (and / or in LMS) remains relevant. Requirements for modern learning systems (and / or LMS), which are developed in accordance with the standard:

– availability of learning components (educational texts, examples of problem solving, tests, control questions, tasks for independent work, tasks for repetition, learning outcomes, etc.) from different access points;

– adaptability of learning content (curricula, training courses, training components, training materials) according to the needs of users and potential employers (stakeholders);

– compliance with new technologies (mobile, cloud, etc.) without additional development;

– use of learning content, regardless of the platform for its creation;

– repeated use of learning content.

Learning content is a set of learning objects collected in courses, chapters, modules, tasks, etc. *Learning object* is any learning material (texts, pictures, audio and video files, flash videos, web pages) that can be displayed in a web browser, and is intended to achieve learning goals in systems that are developed using cloud technologies.

Sharing learning content involves describing appropriate containers for learning components. Each container (zip archive) contains:

– educational materials in the form of texts, .doc or .pdf files, html pages, audio and video files; these materials are structured;

– dynamic content (any Java applets, flash movies, JavaScript code and other objects that can be displayed inside the browser);

– description of the sequence of presentation of learning content.

For example, in the containers that are provided by the SCORM standard, you can pack training courses (in whole or in part). One disadvantage of sharing learning content in this case is that the design of the learning material in the container does not always match the design of the learning system (and/or LMS). The dynamic components of the container can report to the learning system (and/or LMS) data about learning outcomes (for example, the points received by the student for the completed task, and the time spent on this). At the same time, the system cannot find out the content of the task itself.

The SCORM standard assumes the presence of a set of such parts (libraries):

– *Content Aggregation Model* (CAM), which describes the training components, the rules for presenting them to users, the way learning content is stored, labeling it (its individual components), requirements for creating learning content, information about applying metadata to training components inside the container, about the rules organizing and navigating learning content.

– *Run-Time Environment* (RTE) describes: requirements for learning systems (and/or LMS), methods for exchanging data between systems and learning objects, and methods for managing learning processes.

– *Sequencing & Navigation* (SN) describes the rules and methods for sequencing learning content, and how the transition between different parts of the learning content should occur: by what rules, what actions can trigger the transition, what forms of transition times decided which is not.

A learning object developed according to the SCORM standard is designed to add, view, and interact with other learning content components. Such an object is a file or a set of files structured in a certain way and including means for interacting with the learning system (and/or LMS) [2].

The *main flow of events* (typical learning situations) starts when the teacher intends to work with learning courses containing learning objects. The learning system (and / or LMS) provides the following:

1) Adding a course:
   – the system provides a special form for uploading a file;
   – the teacher selects the required zip-file;
   – the system saves the file on the server after it is added.
2) Deleting a course:
   – the teacher deletes the selected course;

– the system deletes files from the server.

3) Interaction with the course:

– the user selects a course to preview;
– the system opens the selected course, interaction with the server begins;
– the user is working with the course.

Alternative flows of events (typical learning situations):

1) Adding is canceled (if during the execution of the "Adding Course" subflow, the teacher decided not to add the course, the addition is not performed, and the main flow starts over).

2) Deletion is canceled (if during the execution of the "Deleting Course" subflow, the teacher decided not to delete the course, the deletion is not performed, and the main flow starts over).

For the software implementation of the SCORM standard, the following libraries are used: SCORM.RTE, SCORM.CAM, SCORM.SN and SCORM.API. Functions from the SCORM.API library allow you to manage learning. Each learning object must include a call to at least two SCORM.API methods, *LMSInitialize()* and *LMSFinish(),* implemented in JavaScript.

Before any actions related to calling functions from the SCORM.API library, search is made for an API implementation provided by the learning system (and / or LMS) – the provider of the learning content. The concrete implementation of the API is launched by the browser, which is an object of the window class and is passed as a parameter to the *findAPI(win)* function.

The browser is the parent object of the object that contains the API implementation. Files that are the implementation of the API in a particular learning system (and/or LMS) are transferred to the system browser in the same way as the learning content itself – at the moment the client browser connects to the server where the learning system (and/or LMS) is located. This implementation is stored on the client during the entire session with the training system (and/or LMS).

Checking the correctness of the sharing of learning content by different learning systems (and / or LMS) should give the following results:

– the course was loaded into the system correctly;
– the system was able to recognize and open the downloaded course;
– the system interacts correctly with the course at the API and user interface levels.

DECISION-MAKING IN A TYPICAL LEARNING SITUATION

Modern learning management processes are associated with the processing of large flows of information. Large amount of information allows you to better prepare a solution, but complicates the search for the necessary data, the integration of diverse information, linking the solution to goals (for example, achieving the necessary competencies), etc.

Intellectualization of management in typical learning situations (TLS) allows you to collect and integrate information about decisions made by different users (students, teachers, methodologists, managers in the learning system, etc.) in a knowledge base (KB), intended for use at the lower level of the hierarchy management of learning processes.

Decisions on the management of learning processes are made in the conditions of the dynamic functioning of learning systems (and / or LMS). Therefore, to describe them, it is advisable to use the methods of situational modeling [16]. The decision-making process in TLS can be represented as a sequence of stages of identifying (defining) a situation (state) and choosing a solution.

There can be many standard solutions in learning processes, and the costs of their automation and intellectualization should not be excessive. The integration of the normative subsystem of HEIs and KB (which stores learning content suitable for sharing by different users and in different educational components) makes it possible to create many automated decision points in TSS based on a single functionality and one information repository.

To integrate the knowledge base and many TLSs related to the management of learning processes (directly teaching, controlling and monitoring students' knowledge, etc.), it is proposed to create an appropriate ontological model that contains definitions of various concepts of learning processes, a description of functions, resources, goals and rules, associated with them.

The ontological model is built on the basis of hierarchies of the <learning_process> type, consisting of <i-level function> elements, which include <operation> elements. <Operation> is function element associated with the implementation of some action to transform resources (for example, a learning object, a learning content component, etc.). Learning processes, functions and operations are connected by relations of "following", "association". All ontology levels are associated with resources, rules, goals.

Refinement of the ontological model (its structure, learning processes, rules, resources, or goals) affects the associated scenarios. In practical aspect, this is the task of classifying and coding fragments of an ontological model of a learning system (and / or LMS) that uses cloud technology. The creation of new rules is associated with various options for replenishing the KB: adding new TLS; clarification of TLS; adding new scenarios and criteria for their selection; clarification of scenarios; clarification of the criteria for selecting scenarios for a state (situation). Different models are used for learning content in knowledge base: network, production, frame, ontological. Knowledge representation can be considered in three aspects: in a normative basis, in the form of an ontological model, and in a knowledge base.

The possibility of converting one representation to another opens up when there is a way to build models of each of the learning systems (and / or LMS) based on homogeneous elements. The basic logical elements for each of the aspects are:

– in the normative basis, this is a description of the learning process (functions, operations) and a set of “IF – THEN” rules (for example, the record “perform knowledge testing monthly” can be represented as a record “if the number N has come, then perform the check”);

– the ontology includes a description of the concepts, functions, resources, goals and rules of the "IF – THEN" type (for example, the relationship between the concepts of "student grades registration log" and "accounting for progress" forms the rule: "if journal of registration of students' grades");

– the knowledge base is built on the basis of a database, where its main component is also a set of " IF – THEN" rules (for example, "if the probability of the scenario of a decision to sign a contract for an internship is greater than N, then we provide this scenario to the head of the internship department").

The rules of inference in the knowledge base may differ in description from the rules in the ontological model and from the rules in normative documents, but they have the same semantic core, and they can be converted from one representation to another.

To create a general model for describing such rules, the concepts are introduced: cause (*Re*), criterion (*Cr*) and result (*Res*). In general, the rule is written as follows: $Re \to^{Cr} Res$, i.e. the fulfillment of certain conditions specified by a criterion or a vector of criteria leads to a certain result. With the help of the above rules, a normative document, an ontological model or knowledge base elements can be described.

Let's consider the KB of learning system (and / or LMS) replenishment scheme. To do this, we denote *Rul* – the set of rules, *F* – the set of associated functions that act as categories for the rules that determine their place in the learning process; *R* is the set of resources that are necessary to implement the rules; *C* – set of conditions (states of TLS); *Sce* is the set of consequences (scenarios of decisions).

More than one decision scenario can correspond to one state of the situation, so we introduce: *In* – set of indicators (measured properties of the TLS state); *Cr* is a set of criteria (ranges of values indicating one or another suitable solution scenario).

Then the ratio of these sets can be represented as follows: $Rul = f(F, R, C, Sce, In, Cr)$

Adding TLS. If there is a situation state C^{new} that does not belong to the set {C}, then adding a new element has the form:

$\{C\} = \{C\} \cup C^{new}$.

Since the state itself does not give a solution, it is necessary to check the fact that there are such Sce_i and Cr_j for which, for certain values of Cr_j: $C^{new} \rightarrow Sce_i$, i.e. the existence of scenarios and criteria for the new situation is checked. Moreover, if such Sce_i and Cr_j do not exist, then Sce^{new} and Cr^{new} are introduced.

Clarification of TLS. If there is a situation state C^k that belongs to the set {*C*} that should be transformed $C^k \rightarrow C^{k\_new}$, then the situation refinement is:

$\{C\} = \{C\} \cap C^k \cup C^{k\_new}$

It is necessary to check the fulfillment of the condition Cr_{jk}: $C^{k\_new} \rightarrow Sce_{ik}$. If it is not observed, then it is possible to switch to the mode of adding new scenarios (if Sce_{ik} does not exist), refining scenarios (if Sce_{ik} exists, but Sce_{ik} does not belong to {*Sce*} for $C^{k\_}$), or refining criteria (if $Crjk \rightarrow \{Cr\}$ для C^{k_new}).

Adding new scenarios. If in the condition Cr_{jk}: $C^k \rightarrow Sce_{ik}$, where Sce_{ik} does not exist, then it is necessary to create Sce_{ik}^{new} that belongs to {*Sce*}, i.e. adding a new script looks like:

$\{ Sce \} = \{ Sce \} \cup Sce_{ik}^{new}$

Clarification of scenario. If there is Sce^h decision script that belongs to {*Sce*} and needs to be converted $Sce^h \rightarrow Sce^{h\_new}$, then the script refinement is:

$\{ Sce \} = \{ Sce \} \cap Sce^h \cup Sce^{h\_new}$

Similarly, there is a refinement of the criteria for selecting scenarios for a particular state of the learning process.

The learning process is a complex function loaded with rules and goals. Some of the operations are linked to TLS states or decision scenarios that are made in these situations. In this case, all operations in the ontological model of organization of learning and management of learning processes that use cloud technologies are related and / or not related to decision making. If the result of a decision-related operation is a TLS state, then it is a *selection operation*. If operation is implemented as a decision script, then it is a *decision operation*. Thus, each operation can be assigned an attribute of connection with decision making from the set: “no connection”, “selection operation”, “decision operation”.

Functions are connected hierarchically, and there are causal relations, association relations, generalization relations, etc. between them. The imposition of relations on the functions of any learning process gives a structure that fits into the essence of the ontological model.

The introduction of the concept of "criterion" into the ontological model, which will physically look like a condition for the implementation of a causal transition (conditional causal relationship) causes the transition from the operation of choice to the operation of decision. Resources (finance, people, electricity, consumables, equipment, software, etc.) for the implementation of a function can be associated with it by an association relationship. To do this, concept of "measurable association relation" is introduced into the ontological model, in which you can specify the required amount of the required resource.

An important aspect of any ontological model is its quality [17]. With operations of choice and decisions, we will correlate the essence of "assessment", which can be formed by an expert or on the basis of knowledge base.

INFORMATION TRAINING SYSTEM BASED ON ONTOLOGY

The main goal of the development and implementation of education is to provide quality education to the user (students, cadets, course participants, etc.), as well as employees of enterprises and organizations in a continuous production process. To improve learning processes at all stages of the life cycle of an educational program, it is advisable to use learning systems (and/or LMS) to monitor and analyze the competencies acquired by users in a particular learning process, both on the part of HEIs and on the part of the state and/or interested enterprises - potential employers.

The *PDCA* cycle is used to manage and improve the quality of training and model building processes. Such a model allows you to define the rules for the interaction of learning processes, identify objects in learning systems (and / or LMS), reflect the sequence of learning processes and performance benchmarks.

To organize learning in the planning process (*Plan*), the regulatory authorities determine the basic requirements for the process of training students, and develop regulatory documents.

The definition of the necessary software, equipment, laboratories, etc. is presented as a function $Z(N)$, which reflects the regulatory documentation for the organization of the educational process (plans, work programs, practices, etc.), where $N = \{n_1, \ldots, n_d\}$ is the set of goals and objectives of the learning processes, including professional retraining programs, d is the number of goals and objectives.

At each stage of training, the professional competencies $PC(L)$ of the learner (student) L can be assessed by a function that reflects labor actions $LA = \{la_1, \ldots, la_i\} \in Q$. Q is a set of competencies that meet the requirements of the state and employers.

The competencies of students, which they must receive after passing the relevant training (training) programs, are established by the state in the form of professional standards for reference books of professional competencies, etc.

The results of the actions performed by trainees in the corresponding training program are determined at the verification stage (*Check*) in the form of a final certification (final control). At the final stage – action (*Act*), it becomes possible to analyze the fulfillment of requirements by regulatory authorities and by employers, new and popular areas of learning are determined, in accordance with professional standards and the relevant requirements of employers, ensuring the competitiveness of the implementation of training (learning) programs.

At the stage of execution (*Do*), HEIs draw up curricula, regulations and work programs for academic disciplines. In the learning process, the learning object L masters all the necessary knowledge and skills along different trajectories, which opens up opportunities for optimizing the learning process.

All objects of the considered subject area (SA) are represented by the values of their parameters. To form various alternative learning chains, we can use the ordering of learning objects according to their similarity by the clustering method, representing the objects as vectors. The numerical parameters of such vectors are attributes of the corresponding learning objects and can be interpreted as the location of the object in some information and learning space, which is supported by cloud technologies.

The choice of any alternative trajectory of the learning process is reduced to the option of choosing the learning components that are taken into the account and is carried out according to a set of complex criteria.

Learning systems (and/or LMS) provide continuous information support for learning processes. For the processes under consideration, a set of criteria for evaluating the quality of competencies has been identified from different positions of participants in the learning processes:

– $Cr_U(X)$ – SVR;
– $Cr_E(V)$ – employer's enterprise;
– $Cr_{Gov}(G)$ – state control bodies;
– $Cr_{EGC}(U)$ – learning system (and/or LMS) administrator.

Strengthening control on the part of the state is reflected in the requirements for users (students, cadets, trainees) - the set $G=\{g_1,\dots,g_k\}$; TEIs define requirements in the form of a set $X=\{x_1,\dots,x_n\}$, which is used in the main criteria. All requirements are analyzed and controlled in the subset $U=\{u_1,\dots,u_j\}$, which allows you to make timely changes to the learning process. Enterprises-employers determine the requirements (set $V=\{v_1,\dots,v_m\}$) for labor skills, necessary skills and knowledge of employees.

An ontological model was built to form the structure of a learning system and/or LMS using cloud technologies. The Protégé ontology editor and the OntoGraph plugin were used as a software tool for ontology creation [11].

The ontological model of the learning system (and/or LMS) can be represented by an ordered triple of the following form [19]: $OM = \langle M, R, U \rangle$, where M is the set of modules of the learning system (and/or LMS); R is the set of relations between the modules of the learning system (and/or LMS); U is the set of functions performed by the modules of the learning system (and/or LMS).

The set of modules M can be represented as a finite set of the form $M = \{M_1,\dots,M_n\}$. The elements of the set M are described by m features $P=\{p1,\dots,pm\}$. Each element M has the form $Mi = \{p^i 1 ,\dots p^i j,\dots,p^i k\}$, where k is the number of instances of the j-th attribute p of element Mi. The set of module functions U can be represented as a finite set of the form $U = \{u1, u2,\dots,un\}$. The elements of the set U are described by a pair of the following form $ui = \{name,\ source\}$, where *name* is the name of the module, *source* is the set of module functions, $i=1,\dots,n$.

In particular, learning system (or the LMS) ontological model takes the following form:

$OM^{LMS} = \{LMS, R, U\}$.

The development of a learning system and/or LMS to monitor and analyze the competencies obtained in the learning process provides for the existence of an appropriate formal model for continuous improvement of the learning process based on the *PDCA* cycle.

In the *Plan* section, the input signal is the value corresponding to the student's competencies – *PC(L)*. Weight is a vector of three elements:

– many requirements for the level of trainees on the part of employers;
– set of goals and objectives of the learning process;
– set of requirements for the competencies of trainees from the state (professional standards, a reference book of professional competencies, etc.).

The “*Do*, *Check*” section involves the implementation of the learning process (according to the learning schedule and schedule, learning sessions are held, including at the material and technical base of the enterprise). The input, in this case, is also the value corresponding to the competencies of the student *PC(L)*, the weight is represented by documentation for the organization of the learning process. The adder block of the “*Do*, *Check*” section is aimed at replenishing competencies with new values.

The “*Act*” section receives competencies as input, supplemented with new values, the weight is a vector of two elements:

– requirements for the level of trainees on the part of employers;
– requirements for the competencies of trainees from the state (professional standards, a reference book of professional competencies, etc.).

The result of the final certification (exit from the “*Act*” section) is recorded in the block for storing the states of the experience gained.

CONCLUSIONS

An ontological approach to building learning systems (and/or LMS) operating in a cloud environment is proposed. It is advisable to use the developed ontological model when implementing learning system (or LMS) in managing learning processes in HEIs.

The constructed ontological model provides an opportunity to implement continuous improvement of learning processes, supporting the sharing by both users (students, teachers, methodologists, etc.) and different training courses of common training content stored in the cloud. The result of using cloud technologies and ontologies is the possibility of making the necessary adjustments to the set of goals and objectives of the learning process, to the learning process, the training course, to the requirements for the level and competencies of trainees on the part of employers (stakeholders) and / or the state.

The developed ontological model of learning processes allows, using cloud technologies, to form a space of learning content.

Sharing learning content across learning systems (and/or LMS) has not only enabled the use of ready-made, high-quality learning materials developed by the best teachers, but also reduced the time and resources spent on transferring content from one system to another.

The proposed approach uses the integration of technologies such as: ontological modeling, intellectualization and informatization, as well as cloud technologies. The use of these technologies makes it possible to predict the occurrence of emergency situations in the learning process.

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ХМАРНІ ТЕХНОЛОГІЇ У НАВЧАННІ: ОНТОЛОГІЧНИЙ ПІДХІД

Анотація. У статті розглянуто онтологічний підхід до створення та використання навчальних інформаційних систем та систем управління навчальним процесом, які функціонують у хмарному середовищі. Запропонований онтологічний підхід дає можливість реалізувати навчальні процеси, підтримуючи спільний доступ як для користувачів (студентів, викладачів, методистів тощо), так і до різних навчальних курсів спільного навчального контенту, що зберігається в хмарі. Результатом використання хмарних технологій та онтологій є можливість внесення необхідних коректив до сукупності цілей і завдань навчального процесу, процесу навчання, курсу, вимог до рівня знань і компетентності студентів. Запропоновано онтологічний підхід до побудови навчальних систем, що працюють у хмарному середовищі. Розроблену онтологічну модель доцільно використовувати при реалізації системи навчання в управлінні процесами навчання у вищих навчальних закладах. Побудована онтологічна модель дає можливість здійснювати постійне вдосконалення процесів навчання, підтримуючи обмін як користувачами (студентами, викладачами, методистами тощо), так і різними навчальними курсами спільного навчального контенту, що зберігається в хмарі. Результатом використання хмарних технологій та онтологій є можливість внесення необхідних коректив до набору цілей і завдань навчального процесу, до навчального процесу, курсу навчання, до вимог до рівня та компетенцій слухачів з боку роботодавців та/або держави. Розроблена онтологічна модель процесів навчання дозволяє, використовуючи хмарні технології, формувати простір змісту навчання. Спільне використання навчального контенту між навчальними системами дозволило не тільки використовувати готові високоякісні навчальні матеріали, розроблені найкращими вчителями, але й скоротило час і ресурси, витрачені на передачу контенту з однієї системи в іншу. Запропонований підхід використовує інтеграцію таких технологій, як: онтологічне моделювання, інтелектуалізація та інформатизація, а також хмарні технології. Використання цих технологій дає можливість прогнозувати виникнення аварійних ситуацій у навчальному процесі.

Ключові слова: онтологічна модель; процес навчання; хмарні технології; інформаційні технології; зміст навчання; навчальна інформаційна система; система управління навчанням.

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