

MODELING COMPETENCES OF A SPECIALIST IN THE DIGITAL ECONOMY

МОДЕЛИРОВАНИЕ КОМПЕТЕНЦИЙ СПЕЦИАЛИСТА В ЦИФРОВОЙ ЭКОНОМИКИ

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Abstracts: *The purpose of the study is the problem of forming a specialist knowledge model. Its relevance is related to the need for an adequate response to strengthening the scientific and technological progress dynamics and the transition to the information interactions economy. The research analyzes the consequences of Russia's entry into the Bologna Convention on education. According to the principle of institutional autonomy, solution of these problems is the responsibility of universities. The paper shows that the way to solve these problems is to transfer universities to a design and technological type of administration. The most promising form of education project management is the model of information interaction within the framework of active self-developing network expert environments. Integration in the natural intelligence network structure forms a collective strategic subject, which is a tool of a knowledge and action synergy in the interaction process. The paper describes the developed structure of the active self-developing network expert environment when forming a specialist knowledge model. It is proposed to consider the construction of specialist's knowledge model in the context of corporate knowledge management strategies in organizations to increase competitiveness as the established support systems for organization knowledge lifecycle and specialist's integral knowledge model are used to integrate strategic corporate tasks with strategic tasks of developing employees' corporate knowledge. They consider a specialist as an element of a company production system. His purpose is to give a product specified quantitative and qualitative parameters that ensure its competitive advantages. To carry out production activities, a specialist uses a complex of abilities, knowledge and skills that should be considered as models of his production and technological activities. At each moment, this complex should be considered as a subjective model of its production and technological activity. This creates a basis for a university self-development process by involving advanced consumers using network technologies in the innovative process of improving educational services, receiving ideas or content by referring to their creative abilities in exchange for a reward that corresponds to a contribution. The paper proposes a system that provides a direction for finding solutions and ideas, as well as filtering, summarizing information, determining its value and prospects. It is shown that the method of improving the quality of solutions on an educational project is the synthesis of crowdsourcing technologies, network expertise and the methodology of the active systems theory.*

KEYWORDS: PROJECT; MODEL; SYSTEM; CONSISTENT MANAGEMENT; SELF-ORGANIZING EXPERT; EXPERTISE; DIGITAL ECONOMY; COMPETENCE

1. Introduction

The competitiveness of countries in the digital economy will depend on the availability of human resources otherwise the country will not be able to realize itself in the digital world. The digital economy involves unprecedented robotization. The firms will be saved the jobs of only the best employees, the rest will act the principle of "go or grow".

Russia's entry into the Bologna Process evoked the problem of specialists' training effectiveness and quality, as well as the problem of integrating higher education institutions into a new social and economic system of the country. According to the principle of institutional autonomy, the primary responsibility for their solution rests with universities [1]. The method of solution is the transition of higher education institutions to the design and technological business type. The relevance of works related to educational projects is also due to the dynamics of scientific and technical progress and the transition to the economy of information interactions [2, 15, 16].

A big number of papers has been dedicated to the problem of designing a specialist's knowledge model. The corresponding bibliography is given in [3-5, 17, 18]. Nevertheless, the problem remains important. The system of personnel training is lagging behind the public demand, industry, etc. [1]. This is due to the fact that the source of changes in the social and economic system of the country and regions is outside the universities due to the specifics of the university system.

The task of monitoring the observed and future sources, which causes the evolution of socio-economic systems, is quite complex under fast pace of changing development paradigms. The corresponding subject area is poorly structured. It is characterized by great uncertainty and most importantly knowledge distribution between carriers [6].

Therefore, the task of knowledge model design should be solved as a task of collective decision-making on a set of agreed compromise versions of curricula for training specialists [7].

2. Principles of creation and application of educational project management systems

The educational organization of a university is created to meet the individual's need for higher education and the needs of society and government in qualified specialists through the provision of educational services. The most promising form of educational project management is a model of information interaction within the framework of active self-developing network expert communities [2]. Such environment contains many experts who are professionals in a relevant field. Appropriate information technologies and Internet facilities provide their communicative interaction. This, in turn, creates an education basis due to a synergetic effect during network interaction of expert professionals of a collective strategic entity that is a carrier of coordinated views and knowledge of the model of specialist's knowledge and competencies. The structure of an active self-developing network expert environment should take into account at least two principles.

The principle of an active external environment. The main elements of the university external environment are educational institutions of secondary education, consumers of educational services and competitive universities in the market of educational services. Therefore, to ensure a balance between internal and external activities of the university, it should be considered as an active multi-agent system.

According to such approach to structuring a university environment puts into correspondence a two-level active multi-agent system. One of the ways to increase the effectiveness of this system is to analyze the needs of consumers in educational services. Naturally, a consumer should have knowledge of the capabilities of universities. This creates the prerequisites for determination of agreed desired states in the space of indicators, both for consumers of educational services and for a university. It also allows choosing the direction and ways of achieving them through determination of an agreed list of competencies, knowledge, skills, structure and the content of transferred knowledge. This way of translating knowledge allows adapting to the requirements of the educational services market, additionally diversifying it.

The coalition principle. This principle involves creation of an active self-organizing expert environment and a structure of an interdisciplinary research system according to the subject-oriented approach. The structure includes a center for interdisciplinary and transdisciplinary studies in the management of educational projects. It includes representatives of various scientific fields and a head of interdisciplinary and transdisciplinary studies in the management of educational projects. The composition of the research group and building models for managing educational projects is formed using the mathematics of the theory of active systems and the information technology of agreement.

The Center claimed to be a coalition for the development of a research methodology on the formation of an educational project content.

3. A mechanism of self-organization of network expert systems in the problem of managing the evolution of specialist knowledge model repair

Building a specialist knowledge model should be considered in the context of corporate knowledge management strategies to enhance competitiveness of a company. The created support systems of a company knowledge life cycle and the integral knowledge model of a specialist are used to integrate strategic corporate tasks with strategic tasks of developing corporate knowledge of employees. A specialist is considered as an element of a company production system. His purpose is to assign a product with specified quantitative and qualitative parameters to ensure its competitive advantages. In order to carry out production activities, a specialist uses a complex of abilities, knowledge and skills that should be considered as models of his production and technological activities. At each moment, this complex should be considered as a subjective model of its production and technological activity [8].

Specialist knowledge management is a way to profit by improving the effectiveness and quality of his behavior in solving production problems. The behavior of a specialist in a company is determined by: 1) his expectations in meeting his needs as an individual; 2) his qualities as a person and a specialist, some of which are formed under the influence of activity; 3) evaluation of the results of his activities by the company and his subjective assessment. An activity has obvious and implicit behavioral indicators, their data are in the activity results. Applied methods of action and their observed effectiveness, the obtained results contain information about a pattern of behavior. Modeling of behavioral patterns from three positions was considered in [9]. The discrepancy between the actual and required knowledge model determines requirements for investing in a knowledge system of an organization and hence to target indicators of a university educational process. Network technologies create a mechanism for identifying requirements for the quality and structure of educational services, determining the direction of their development. They are the basis for information support for the innovative process of transforming a knowledge and competencies model of a specialist, which forms the basis for a self-development process of a university. An important component of the process is the system that directs the search for solutions and ideas for making decisions on building a specialist model. The basis for its creation should be the synthesis of crowd sourcing, network expertise and methodology of the theory of active systems.

The proposed approach allows considering the process of extracting new ideas and knowledge as an active system with heterogeneous agents with a counter way of communicating information and active influence of a center in the form of queries to obtain reflexive estimates [10, 11].

The information exchange between the center and experts is an interactive and iterative process. In this case, crowdsourcing tools are used for preliminary processing of information coming from experts, including filtering, characterization, semantic clustering, building ontologies, etc. Processing is aimed at speeding up the process of building an agreed choice model in a network expertise and its translation into the system environment using data mining tools. The center completes semantic clustering and a subject

domain ontology, forms a model of a specialist, assesses the consistency of various solutions, develops its own version on their basis, and performs its evaluation. To coordinate it, the center forms queries and informs experts of its solution. The information exchange between the center and experts continues until a solution is agreed.

Methods for describing a structure of representations of active environment subjects, conditions for identity, regularity, correctness, differences in information awareness of subjects, as well as conditions for dynamic information equilibrium existence, and models of coordinating representations in the communication process are given in [6, 11].

4. Reflexive coordinated management of an educational project

Achieving the goal of the project involves formation of a coordinated decision on the model of competences and knowledge, fixing it as beliefs among students, methods, means of developing creative thinking and ways of acting in typical situations. To solve this task means to activate all kinds of reflective thinking among project participants. Before choosing a solution, it is necessary to obtain information about possible alternatives (for example, as a range of solution options). Necessary conditions for their formation are information actions performed according to the TOTE model developed by R. Bandler and R. Dilts [12]. This model makes it possible to describe and form human mental and behavioral programs to achieve the goal through a variety of means. Description models using the concept of TOTE are well formalized by structural programming and can be successfully described using algorithms.

The behavior of agents who are project participants is determined by their model of subjective representations, which connects a state of agent's environment, modes of its operation and a result (material or spiritual). When planning their behavior, agents predict a state of the environment, possible results, their value, a mode of action. When assessing a result of their behavior, agents monitor and evaluate their performed actions, obtained results, a value of a result and value of their behavior in general. These assessments form states of satisfaction and conviction. Satisfaction represents an integral feeling or emotion. It is determined by a combination of specific, particular feelings and emotions from the obtained result or the possibility of obtaining it. In the process of behavior, an agent solves some problems. The task is the desired result the agent seeks for some time, and he breaks the task into a sequence of steps to achieve it. At each stage k , the agent edges towards a solution of a problem, and the expected value of an intermediate result (the objective function $f(y_j[k])$) increases monotonically following

its results [13].

The expert can solve the problem of modeling individually or as part of a decision-making group, which includes a purposeful center and other purposeful agents. In the first case, he chooses a solution that satisfies him or tends to get an optimal result. Here he must be sure of the possibility of obtaining it. In the second case, purposeful agents choose a solution that satisfies all agents, and all of them are sure of it (evaluation of decisions). A coordinated optimization of satisfactory solutions of the problem leads to an optimal solution. Linguistic and representative variables, criteria and goals help to measure the values of membership functions of fuzzy set elements (for example, ideals or goals), which are measures of satisfaction and conviction intensity of a purposeful agent (expert). A linear convolution algorithm with significance coefficients evaluates the degree of solution consistency.

When decisions of the participants are agreed, as in expert assessment methods, a set of criteria for specific j -th participants is compared with the experience in the "experiment". Let us consider a certain goal and its corresponding criterion $k(w)$. We will perform its decomposition, obtain a second level objective tree and a corresponding tree of criteria:

$$\mu_D(k(w)) = \sum_{i=1}^n a_i(k(w)) \times \mu_{G_i}(k(w)) + \sum_{j=1}^m \beta_j(k(w)) \times \mu_{C_j}(k(w)),$$

where a_i, β_j are coefficients of criteria significance.

Here, there are membership functions of subjective ideals and goals of purposeful agents. A membership function of an ideal and a goal is determined using associations, intersections and their combinations of fuzzy sets of ideals, goals and constraints of the second, third and further levels.

Let us consider goals in the form of associations of fuzzy sets at each level [9]. There can be several levels. For the sake of simplicity, we will consider two levels. Let there be m goals at the

second level. We define, $\mu_D(w) = \bigcap_j^m \mu_{G_j}(w)$, or taking into

account the coefficients of significance $\mu_D(w) = \bigcap_j^m a_j \mu_{G_j}(w)$,

therefore $\mu_D(w) = \mu(\bigcap_j^m a_j \mu_{G_j}(w)) = \min\{a_j \mu_{G_j}(w)\}$.

The next level has several goals $G_{ij}, i = 1, \dots, n, j = 1, \dots, m$

$$\mu_D(w) = \bigcup_i^n a_i (\bigcap_j^m a_{ij} \mu_{G_{ij}}(w)),$$

$$\mu_D(w) = \bigcap_i^n a_i (\bigcup_j^m a_{ij} \mu_{G_{ij}}(w)).$$

Convolution of particular indicators into a complex estimation is performed using network programming methods, which are based on the representation of an objective function and problem constraints as a superposition of simpler functions [14]. If an expert is satisfied with the received solution and image in the form of TOTE, sure of this and agrees with this, then he proceeds to forming the next TOTE, i.e. to the next part of an educational project according to the hierarchical structure of the set of forming TOTE. Otherwise, the whole procedure is repeated. At the same time, the information coordination technology should coordinate information of a conscious and unconscious expert.

To describe a group behavior of experts in informal and formal communication we apply a model of the constant updating of *IWRA* knowledge [12]. *I* means individual contributions of each expert to the solution of a common task (*W*) based on insight, intuition and knowledge with different values and abilities.

Based on communicative interaction, experts develop an agreed view of a choice situation, determine the direction of advance towards the subjectively understood ideal, and develop adjustments (*A*) in organizing and developing ways of acting to achieve a common goal.

5. Making agreed decisions in the problem of forming a knowledge and competencies model of a specialist

For the purposes of a formal analysis of self-organizing expert system functioning, we will consider its model, which consists of an interdisciplinary research center and experts (agents). According to [11] the functional problems of the center are:

1. Formation of an agreed perception of the state of corporate knowledge management strategies in companies and the possibility of a university to participate in their implementation;
2. Formation of an agreed idea on the educational services structure and content in a purposeful state situation;
3. Determination and coordination of university survival and development goals based on agreed ideas;

4. Development of coordinated management taking into account the interests of a university and consumers of educational services;

5. Optimization of generalized indicators of system performance effectiveness.

Let u be the center control (a version of a curriculum and a competency list). A vector of agent controls (informational reports of experts) is $v = (v_1, v_2, \dots, v_n)$. The last two problems can be solved as follows:

$$(u, v) \in \Omega, \tag{1}$$

where Ω is a set of controls that convert the system into one of the states of the set X^* ($X^* \subseteq X$ is an area of desired states of the system). Controls (1) might be determined based on some set of assumptions about a behavior and nature of system agents' awareness:

1. the center can define the desired state of the system as a set of generalized indicators that are functions of parameters of agent messages. Generally, the center does not know particular dependencies. However, to determine them, it can use information about the results obtained by competitors in this market sector and the results of network expertise. We will call such inferred knowledge the perception of the center about the state of a company knowledge system, possibilities and direction of educational system development;

2. based on agents' messages and representations of desired states, the center can determine management (a plan of actions and information request) $u \in U$ and inform its agents;

3. during the known control u , the i -th agent chooses its control $v_i \in V_i(u_i)$, which converts him into the state $y_i \in Y_i$,

where Y_i is a set of possible states. We will assume that agents are interdependent in the choice of their states. It means that they

consider global constraints $Y^{2..n}$ when choosing. Therefore, according to the condition (1), the system can be in one of the

following states $Y = Y^{2..n} \cap (\bigcap_{i=1}^n Y_i)$. Here $\bigcap_{i=1}^n Y_i$ is a set that is

$$i = 1 \quad i = 1$$

determined by local restrictions that experts know;

4. let agent's behavior correspond to the hypothesis of rational behavior. Then the choice of the agent's message will be aimed to maximize its subjectively understood effectiveness criterion $G_i(u, v_i)$;

5. in general, the center does not know exactly about control space and agents' effectiveness criteria. So it must organize information exchange with agents to create his vision of their desired states. For this purpose, he requests the agents to assess the quality of their views u and desired states y_i , clarifies their interests around the obtained solution in exchange for incentives for receiving counter information;

6. after receiving new information, the center recounts the solution and asks agents new questions until he receives an exact or close solution.

These assumptions allow formulating a problem of determining a set of specialist model variants by the center as a set of his admissible controls

$$U^0 = \left\{ u \in U \mid V(u) = \prod_{i=1}^n V_i(u) \neq \emptyset, \right. \\ \left. (u, v) \in \Omega, \forall v \in R(u) = \prod_{i=1}^n R_i(u) \right\}, \tag{2}$$

where $R_i(u) = \text{Arg} \max_{v_i \in V_i(u)} G_i(u, v_i)$.

Let the center estimate the states of satisfaction and conviction from the obtained version of a specialist knowledge and competences

model using an efficiency criterion $F(u, v)$. Then he can form such version of messages for experts that is optimal guaranteeing control for him, determined as:

$$F^0 = \sup_{u \in U^0} \inf_{v \in R(u)} F(u, v) \tag{3}$$

Common interests of the center and agents are guaranteed by the condition of obtaining total benefit

$$\sum_{i=1}^n G(u_i, v_i) + F^0 \leq C(\bar{Y}) \tag{4}$$

where \bar{Y} is the expected profit from a company knowledge system development, $C(\cdot)$ is a material incentive fund or a pay-roll fund for experts.

Consequently, the considered system is a system with interests that are no opposite, since the amount of income received depends on their total efforts. Then the choice of an agreed vision of a knowledge model and specialist's competencies should be made using a variety of compromise options. The purpose of an agreement is to achieve terminal payoff. It can be succeed by reporting reliable information and cooperative solving problems, which is a guarantee of convergence of data exchange. The structure and content of expert's messages is determined by solving the following problem. Each i -th agent builds a model of a management object describing it with a level of costs y_i^{ex} , a level

of output y_i^{blx} and a set of action modes z_i , by which an agent guarantees the output of products and services of the required assortment and quality. The modes of action z_i are determined by its competencies, knowledge and experience. Then the considered set of possible states of i -th agent is determined as follows:

$$Y_i = \left\{ \begin{array}{l} y_i | y_i^{-ex} \leq y_i^{ex} \leq y_i^{-ex}, \\ y_i^{blx} = w_i(y_i^{ex}, z_i) \in Y_i^{blx}, z_i \in Z_i \end{array} \right\} \tag{5}$$

The task (1–5) of determining a knowledge model and competence should be considered as the task of searching a maximin with bound constraints.

When determining the mode of action, the i -th agent solves its locally optimal problem. So, $y_i^{blx} = w_i^*(y_i^{ex}, z_i) \in Y_i^{blx}$ should be considered as a model of agent's vision of control object operation. Therefore,

$$Y_i^* = \left\{ \begin{array}{l} y_i | y_i^{-ex} \leq y_i^{ex} \leq y_i^{-ex}, \\ y_i^{blx} = w_i^*(y_i^{ex}, z_i) \in Y_i^{blx}, z_i \in Z_i \end{array} \right\}$$

can be considered as agent's subjective vision of the set of possible states that he can communicate to the center. Obviously, it is determined by his knowledge, experience and corporate strategies of his development.

The center forms its own vision of knowledge system development in corporations and companies taking into account national interests

$$Y_i^* = \left\{ \begin{array}{l} y_i | y_i^{-ex} \leq y_i^{ex} \leq y_i^{-ex}, \\ y_i^{blx} = w_i^u(y_i^{ex}, z_i) \in Y_i^{blx}, z_i \in Z_i \end{array} \right\}$$

The desire of organizations to increase their effectiveness and competitiveness makes it possible to guarantee that the center will be fully informed of capabilities, desired states of agent's knowledge system within the accuracy of parameters. It means that the center receives all necessary information about models of competencies and knowledge of specialists from agents, but does not know their choice. In [8] it is shown that based on this

knowledge the center calculates control $u^0 \in U^0$, and an agent makes only one information message by selecting its state y_i and control v_i from the set $B_i(u_i) = Y_i(u_i) \cap Y_i$, maximizing the value of its objective function

$$G_i(u_i, v_i) \rightarrow \max_{v_i \in B_i(u_i)} \tag{6}$$

Therefore, the center has the result of choice of all agents belonging to the set $R(D)$, where $D = Y^{2,n} \cap \prod_{i=1}^n B_i(u_i)$ is a set of possible states of the whole system. Changing the control $u = \{u_i, i = \overline{1, n}\}$, the center can play possible scenarios of system behavior.

6. The algorithm for constructing a set of possible messages by an agent

An agent determines the direction of his development by analyzing his opportunities and trends in market dynamics. When the center communicates a version of a competence and knowledge model u_k , the agent can determine for himself, by solving the problem (6), such a vector of vision of a knowledge model $x_k^{(h)}$, that allows

expanding the set $X_k^{(h)}$ of center's visions of his needs, where h is a step of the iteration process. We denote a vector of expansion parameters of the set of possible states of an organization knowledge model through $\omega_k = \{\omega_k^{(h)}, h = \overline{1, H}\} \in A_k$. Obviously, it will determine the values of the vector $x_k^{(h)} = \{x_{kj}^{(h)}, j \in \overline{1, m_k}\} \in X_k^{(h)}$. Therefore, this vector describes agent's knowledge of the possibilities of developing an organization knowledge system. Here A_k is a set of possible values of the state vector. We assume that an agent has abilities that guarantee existence $\Psi_k: A_k \rightarrow X_k^{(h)}$. So he is able to change his knowledge system for the company.

A level of knowledge about requirements of the market to the volume and quality of produced products and services available to an agent makes it possible to assume the existence of a limited set of A_k state parameters for the k -th agent. Let us denote an achievability set or a set of limit possibilities through $O_k^* = \{o_k^*/o_k(x_k), x_k \in X_k^{(h)}(\omega_k^{(h)}), \omega_k^{(h)} \in A_k\}$. According to the hypothesis for locally optimal agent behavior, due to his creative abilities, self-learning and searching for new information under appropriate stimulating influence, an agent is able to

determine such states $\omega_k^{(1)} \in A_k$ and $\omega_k^{(2)} \in A_k$, that $\omega_k^{(2)} \succ \omega_k^{(1)}$ is possible, where the symbol \succ means "more meaningful". At the same time $X_k^{(1)}(\omega_k^{(1)}) \subseteq X_k^{(2)}(\omega_k^{(2)})$.

Therefore, there exists a sequence $\omega_k^{(1)}, \omega_k^{(2)}, \omega_k^{(3)}, \dots$, so that

$$\lim_{h \rightarrow \infty} o_k^{(h)}(x_k^{(h)}(\omega_k^{(h)})) = O_k^*. \text{ It guarantees that an agent gives}$$

the center reliable information about requirements for a specialist competency and knowledge model. Agent's ability to form an expanding set of knowledge and competencies model options results from the following properties of his target function:

$$\forall \omega_k^{(1)}, \omega_k^{(2)} \in A_k, \omega_k^{(2)} > \omega_k^{(1)}, \\ X_k^{(1)}(\omega_k^{(1)}) \subseteq X_k^{(2)}(\omega_k^{(2)}) \mapsto E\varphi_k(x_k^{(2)}) > E\varphi_k(x_k^{(1)})$$

This condition determines agent's motivation and purposefulness. So, when crossing a certain threshold of changing the value of a purposeful state situation by the result of $\Delta = E\varphi_k(x_k^{(2)}) - E\varphi_k(x_k^{(1)})$, an agent is able to identify preferred modes of action and sees the possibilities of changing the structure of his knowledge.

7. Conclusion

The paper describes an attempt to research educational project management using a transdisciplinary approach. The research applies modern approaches of the theory of active systems, psychology, neurolinguistic programming, management in social and economic systems. The authors consider the problem of investigating reflexive management processes in formation of a knowledge and competences model, which is an important part of educational projects, especially for new promising areas that have no analogues. Its solution is associated with management tasks, personal knowledge of experts, and corporate strategies for managing an organization knowledge system.

Experts are considered as carriers of new knowledge obtained in active scientific research. It is shown that the formation of a specialist knowledge and competence model in the context of uncertain and poorly structured information is in implementation of consistent procedures for agreeing the views of producers and consumers of educational services.

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