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COGNITIVE MODELING OF LEARNING PROCESS

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Abstract

This article examines the model of the transition of the educational system to a higher level of education for the acquisition of appropriate competencies by students. This work was carried out in accordance with the new Russian state educational standards of generation 3++. As a basic formalism, a model of the dynamics of competence growth obtained using cognitive modeling is considered. The methodology of modeling the process of increasing the student's competencies over time is proposed. It is proposed to use an integral indicator of the level of the educational system in the form of the sum of competencies accumulated by the student at a certain moment in accordance with the requirements of the educational standard and taking into account their expert-defined weights. For this purpose, cognitive maps have been developed that describe the relationships between the parameters of the system. The factors included in the cognitive map are divided into controlling and controlled. The acquisition of competencies is a dynamic process, so it is presented in the form of a discrete-time equation. The dynamics of managing the growth of competencies in the educational system as the learning time changes is considered. The use of cognitive maps allows us to assess the relationship between the most important factors of the process, to build a dynamic model of the management system that allows us to solve both the tasks of stabilizing the level of the educational system and the tasks of its transition to a new, higher level.

Keywords: Learning systems, competition approach, cognitive simulation

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1. Introduction

The current transition of higher professional education to the introduction of the requirements of professional standards is associated with serious changes in the methodology and technology of the educational process. To a large extent, this is due to the need to introduce a competency-based approach to teaching students, when the focus is on the ability to creatively apply the acquired knowledge, skills and abilities, and, as a result of training, correspond to the level of qualification in their field, to have practical skills in the profession.

This direction lies within the framework of the planned work on the creation of the National Qualifications System (NSC) of the National Qualifications Development Agency.

For translation educational systems to a new level, certain efforts are required both from within the system itself and from outside - in the form of investments in the development of human resources, improvement of the material and technical base, informatization, improvement of management.

2. Problem Statement

When trying to quantitatively describe this process, the key problem is to choose some integral indicator that could adequately characterize the level of the system as a whole, as well as evaluate the control actions.

Previously, a model was proposed based on the assumption that the level of the educational process is determined by the level of use of information technology in the learning process (Dorrer et al., 2008).

This work can be seen as a step towards realizing the goals of the NSC.

The article proposes an integral indicator of the level of the educational system in the form of the sum of competencies accumulated by the trainee by a certain moment in accordance with the requirements of the educational standard and taking into account their expertly determined weights. This indicator is used both to assess the state of the educational system and to make decisions on managing its development. For a more complete assessment of the required competencies, it is also necessary to involve professional standards from the field for which specialists are trained, as well as the specific requirements of employers. At the same time, a separate task is to link the required competencies to the disciplines taught and then to the didactic units studied in each of the disciplines. It should also be taken into account that the increase in competence to a large extent occurs during the passage of practices at enterprises and in the preparation of final qualification works.

The second essential point of the proposed work is the use of cognitive modeling methods (Mikryukov & Mazurov, 2022; Moskaleva & Dorrer, 2012) to assess the relationship between the most important factors of the educational process, which allows building dynamic models of competency growth depending on the control factors. At the same time, the task of management is to ensure that the actual growth of students' competencies in the process of their learning does not lag behind the level, which is determined by the requirements of the state standard.

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3. Research Questions

The definition of an integral indicator that characterizes the required level of competencies accumulated by a trainee is shown on the example of taking into account the requirements of the Federal State Educational Standard of Higher Education in the direction of bachelor's training 09.03.01 - Informatics and Computer Engineering.

When compiling the working curriculum in this area, these competencies were tied to the disciplines and then were reflected in the working curricula of the disciplines.

The total number of references to the relevant competencies in all disciplines in each semester and the rate of their accumulation is taken as an indicator of the required level of the educational process in mathematical modeling and management of this process.

4. Purpose of the Study

The following goals are defined (Mikhailov et al., 2019).

- Provision of the state and business with the necessary tool for managing the competencies and qualifications of human resources in order to support newly created high-tech organizations and other needs of the innovative economy.
- Strengthening the motivation of specialists for self-development by raising the social status of professionals in society.
- The ability to synchronize the educational and professional career paths of citizens with the development plans of the country or companies.
- Creation of a modern infrastructure of the economy based on knowledge for the accelerated development of the country's professional potential, ensuring the global competitiveness of its leading industries and individual companies.
- Ensuring a flexible relationship between the needs and forecasts of the labor market in competencies with the system of general and vocational education.

5. Research Methods

5.1. Cognitive model of the educational process

The educational process in an educational institution is a complex, semi-structured system that depends on a large number of vaguely defined factors. As is known (Mikryukov & Mazurov, 2022), one of the ways to describe such systems is the use of cognitive modeling, in which the description of the relationship between system parameters is given in the form of cognitive maps.

Cognitive Map (Cognitive Map from cognitio - knowledge, cognition) is a tool of cognitive modeling methodology designed for analysis and decision making in ill-defined situations. It is based on modeling the subjective perceptions of experts about the situation and includes:

- methodology for structuring the situation;

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- a model for representing expert knowledge in the form of a signed digraph (cognitive map) $CM = \{F, W\}$, where *F* is the set of basic factors (concepts) of the situation, *W* is the set of cause-and-effect relationships between the factors of the situation.

A cognitive map can be understood as a schematic description of the worldview of an individual related to a given problem situation. Therefore, with the construction of cognitive maps, one can begin the study and modeling of complex semi-structured systems to find alternatives to a decision and make it.

A cognitive map can be visualized as a graph containing many vertices, each of which corresponds to one factor or element of the individual's worldview. The labeled arc connecting vertices *A* and *B* corresponds to a causal relationship $A \Rightarrow B$,where *A* is the cause, *B* is the effect. A relationship $A \Rightarrow B$, is called positive (marked with a “+”) if an increase in *A* leads to an increase (strengthening) of *B*, and a decrease in *A* leads to a decrease in *B*, all other things being equal. The “–” sign above the arc means that the relationship is negative, i.e. ceteris paribus, an increase in *A* leads to a decrease (inhibition) of *B* and a decrease in *A* leads to an increase in *B*. On a cognitive map, in addition to the sign, one can indicate the relative degree of influence of one factor on another in the form of a numerical assessment (for example, in the range from +1 to - 1). In this case, we obtain fuzzy cognitive maps.

Cause-and-effect relationships can also be described as a weight matrix *W*, which displays the influence of each factor on all the others.

As an example, let's consider simplified versions of cognitive maps compiled by the authors for the aforementioned area of bachelor's training on 09.03.01 (we will take universal and professional competencies for analysis) based on a survey of specialists working with students in this area (Tables 1 and 2). These maps provide a list of factors of the educational process and consider their interaction, the influence on each other, including the level of competence.

The map for assessing universal competencies includes 3 competencies from the list given in table 1. It is compiled using a continuous scale of assessments of the influence of factors lying in a continuous range from -1 to +1.

The map for professional competencies contains three groups of competencies from the specified list, and the assessment of the influence of factors is carried out using three values: -1, 0 and +1.

As experience shows, the compilation of cognitive maps is a rather complicated process that requires careful selection of experts and gradual coordination of their opinions. However, this issue is not discussed in this work.

Table 1. Cognitive map for assessing factors influencing the universal competencies of students

№	Name of factors	1	2	3	4	5	6	7	8	9	10	11
1	Teacher Qualifications	0	0	0.7	0	0	0	0	0	0	0	0
2	Educational and methodological support	0.8	0	0.8	0	0	0,4	0	0.5	0.4	0.4	0
3	Hardware and software	0.9	0.8	0	0	0	0	0	0	0.6	0	0
4	Living conditions	0	0	0	0	0	0	0	0	0	0	0
5	Pre-university education	0	0	0	-.2	0	0	0	0	0	0	0
6	Ability to work in a team	0.5	0	0.4	0.2	0.1	0	0.6	0.3	0.3	0.5	0.5

7	Ability to build oral and written speech	0.7	0	0.1	0.3	0.6	0.9	0	0.7	0.8	0.2	0.5
8	Foreign language proficiency	0.3	0	0.5	0.3	0.8	0.2	0.8	0	0.4	0.6	0.3
9	Ability to work with documents	0.4	0.3	0.4	0.1	0.2	0.1	0.7	0.6	0	0.7	0.2
10	Motivation for learning	0.3	0.6	0	0.8	0.7	0.9	0.8	0.5	0.3	0	0.7
11	Social adaptation	0.3	0.5	0	0.7	0.7	0.8	0.6	0.3	0.7	0.7	0

Based on the above tables, weight matrices were compiled for universal and professional competencies - respectively W_{ok} and W_{pk}.

As shown in Moskaleva and Dorrer's (2012) research, the analysis of these matrices makes it possible to judge the stability of the process described by this cognitive map. To do this, it is necessary to analyze the eigenvalues of the matrix W, and if they all lie inside the unit circle on the complex plane, then the system is stable, but if at least one eigenvalue is greater than one in absolute value, then the system is unstable.

In particular, for the considered cognitive maps, we obtain the following results.

Table 2. Cognitive map for assessing the factors influencing the professional competence of students

№	Names of factors	1	2	3	4	5	6	7	8	9
1	Teacher Qualifications	0	1	1	0	1	0	0	0	1
2	Educational and methodical. security	1	0	0	0	-1	0	1	1	0
3	Techn. and software	1	1	0	0	0	1	1	1	0
4	Living conditions	0	0	0	0	-1	0	0	0	1
5	Pre-university education	0	0	0	-1	0	0	0	0	1
6	Design and technological activities	1	1	1	0	0	0	1	-1	1
7	Research activities	1	1	1	0	1	0	0	0	0
8	Scientific and pedagogical activity	1	1	1	0	1	0	0	0	0
9	Motivation for learning	1	0	0	0	1	0	0	1	0

For the cognitive map of universal competencies, the maximum eigenvalue is 4.34, which indicates the instability of the system. In the case under consideration, the instability of the process described by the cognitive map indicates the positive dynamics of the system, its ability to self-develop.

For one of the blocks of the cognitive map W_{pk}, the maximum eigenvalue is 1. This indicates that the system is on the border of stability and is not capable of self-development.

Model of educational system dynamics.

For further analysis of the system and building a model of the control system, all factors included in the cognitive map can be divided into control and manageable. Those factors that are available for variation and that can influence the rest should be referred to as control factors, and the rest of the factors, including the target ones, become controllable. The latter include levels of competence. Considering that the

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acquisition of competencies is a dynamic process, it should be represented as a discrete time equation based on a cognitive map

Turning to the construction of a model of the educational process, we will consider it as a sequence of certain stages (for example, semesters) during which learning takes place, i.e. increasing the competence of trainees.

Let us introduce the following notation:

$t = 0,1,2,...,T$ - discrete time (months, semesters, years - depending on the specifics of the task), *T* - depth of process planning;

$x = 0,1,...,N+1$ – stages of the educational process (for example, semester numbers); *x=0* corresponds to the applicant, $x = N+1$ corresponds to the graduate;

$P(t,x)$ – *n*-vector of factor values that determines the current state of the system (including the level of competence of trainees), where n is the number of factors taken into account in some conventional units.

Let's single out the input and output factors in the list of factors. Renumbering the factors, if necessary, so that the input factors are at the beginning of the list, we represent the column vector *P(t, x)* in the following form

$$P(t,x) = [U(t,x) \quad S(t,x)]^T, \quad (1)$$

where $U(t,x)$ – *m*-vector of input factors, *S(t,x) – n-m*-vector of controlled factors. The *T* sign means matrix transposition.

The weight matrix *W* can be represented in the following block form

$$W = \begin{bmatrix} D' & C \\ B & A' \end{bmatrix}. \quad (2)$$

Here:

B is a matrix of dimension *m*(n-m)*, which determines the impact of input factors on the controlled ones,

A' – matrix of dimensions *(n-m)*(n-m),* which determines the mutual influence of controlled factors,

C - matrix of dimensions *(n-m)*m*, which determines the influence of controlled factors on the input,

D' is a matrix of dimensions *m*m*, which determines the mutual influence of input factors.

We assume that the matrix *W* is unchanged for the entire period of study and that the discrete time coincides with the stage of the educational process, i.e. with the semester number, so *x=t*.

Then the dynamics of the educational system, which develops both according to its own internal laws and under the influence of input influences, can be represented by the equation

$$P(t+1) = P(t) + \Delta P(t) + \xi(t) = P(t) + W \cdot P(t) + \xi(t), \quad (3)$$

where $\Delta P(t) = W \cdot P(t)$ is the increment of the parameter vector in one time step (per one stage of the educational process), which is also called an impulse in the literature (National Qualifications System (NSC) National Qualifications Development Agency, 2022), $\xi(t)$n is the vector of random noise affecting the educational process.

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Equation (3), taking into account the structure of the vector *P(t)* (1), the matrix *W* (2), and the rules for working with block matrices, takes the form

$$P(t+1) = \begin{bmatrix} U(t+1) & S(t+1) \end{bmatrix}^T = \\ = \begin{bmatrix} U(t) \\ S(t) \end{bmatrix} + \begin{bmatrix} D' & C \\ B & A' \end{bmatrix} \cdot \begin{bmatrix} U(t) \\ S(t) \end{bmatrix} = \begin{bmatrix} D+I_m & C \\ B & A'+I_{n-m} \end{bmatrix} \cdot \begin{bmatrix} U(t) \\ S(t) \end{bmatrix} = \\ = \begin{bmatrix} (D+I_m)\cdot U(t) + C\cdot S(t) + \xi_1 & B\cdot U(t) + (A'+I_{n-m})\cdot S(t) + \xi_2 \end{bmatrix}^T. \quad (4)$$

Here I_m and I_{n-m} are identity matrices of the corresponding dimension.

Denote

$$(A' + I_{n-m}) = A \,, \; D' + I_m = D \quad (5)$$

Since we are interested in controlled factors (including target ones - indicators of competence), and the influence of matrices *D* and *C* can be ignored, then the vector equation (4) should consider only the second component. As a result, we obtain an equation for the dynamics of controlled factors in the form of a standard linear equation for a controlled system in discrete time:

$$S(t+1) = A \cdot S(t) + B \cdot U(t) + \xi_2(t), \quad (6)$$

Here

t=0,1,…,T, $\xi_2(t)$ – *n-m* - random noise vector.

Vector *U(t)* is the control and is set during the study according to the scenario of the system development. Matrices *A* and *B* allow us to evaluate the controllability of the system, i.e. its ability, due to the choice of the control action *U(t)*, to obtain the required values of the controlled parameters (Zhilov, 2016).

System (6) should be considered under the initial conditions:

$$\text{at } t = 0 \; S(0) = S_0, \quad (7)$$

where S_0 is the given initial distribution of controlled factors.

5.2. Models of the educational system management process

Consider the procedure for assessing control actions. Since both control and controlled factors are vectors - *U(t)* and *S(t)*, respectively, the task of managing the educational process is a multicriteria and multivariate task. Therefore, to study the dynamics of the system, a scenario approach will be applied, in which the values of the control factors are set expertly and, using a mathematical model, the values of the output factors are calculated. In this case, the control law of the system depends on its dynamic properties determined by the eigenvalues of the matrix *A*. If the system is stable, i.e. Since all eigenvalues of the matrix A lie inside the unit circle, then additional external influences are required to transfer it to a new level. If the system is unstable, i.e., capable of self-development (the matrix *A* has eigenvalues, modulo greater than 1), then to move to a new level, it is necessary to turn off the stabilization mechanism and set the initial conditions correctly.

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So, two modes of operation of the system will be considered:

1. maintaining a steady state of operation,
2. transfer of the system to a higher level of functioning.

Let us consider the control models for the indicated modes.

With a steady process, this function should ensure the maintenance of a given level of controlled factors $S_u(t)$, providing negative feedback on the deviation from the required level:

$$U(t) = K(t)(S(t) - S_u(t)), \quad (8)$$

Where $K(t) - m * (n - m)$ is the matrix of influence coefficients that determine the speed at which the level of controlled factors at all stages of the educational process approaches the required level Su when the system is unbalanced.

It is easy to see that if there is a property of controllability of the system, a small amount of interference, and after a sufficient time has elapsed, the educational process will "attract" to the required level S_u and will fluctuate around it under the influence of interference. The meaning of the coefficients of the matrix *K(t)* is that they determine the efficiency of the system self-regulation process, i.e. level of management and management.

Transfer of the system to a new level of functioning. Let us now consider the case when the educational process needs to be transferred from some achieved level $S_1(x)$ to a new, higher level $S_2(x)$. Here an important role is played by the ability of the system to self-development, which is determined by the properties of the matrices W and, in particular, by their own numbers, and, ultimately, by cognitive maps that reflect the opinion of experts.

If the educational system is capable of self-development, then control actions should only be of a corrective nature to bring priority competencies to the required level.

In the case when the system is not capable of self-development, certain external efforts are required to move to a new level. The system needs to overcome the attraction of the level $S_1(x)$, and then move to the area of attraction of the level $S_2(x)$. Then, after a certain period of time, the process will be established in the region of the new center of attraction. The features of such control are considered in (Dorrer et al., 2008).

6. Findings

6.1. Model for the growth of universal competencies

Let us consider the dynamics of managing the growth of universal competencies in the educational system based on the cognitive map (Table 4) and the model outlined above.

Based on the list of factors given in the cognitive map, we choose the following as control factors (components of the *U* vector).

U_1- Qualification of teachers,

U_2 - Educational and methodological support,

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U_3 - Hardware and software,

U_4 - Living conditions,

U_5 - Pre-university education.

We will choose the following competencies as controlled factors (components of the vector *S*).

S_1 - Ability to work in a team,

S_2 - Ability to build oral and written speech,

S_3 - Proficiency in a foreign language,

S_4 - Ability to work with documents,

S_5 - Motivation for learning,

S_6 - Social adaptation.

Having compiled a matrix of mutual influences of W_{ok} factors in accordance with Table 4, presenting it in block form in accordance with formulas (2) and (3), we obtain the matrices *A* and *B*:

$$A = \begin{pmatrix} 1 & 0.6 & 0.3 & 0.3 & 0.5 & 0.5 \\ 0.9 & 1 & 0.7 & 0.8 & 0.2 & 0.5 \\ 0.2 & 0.8 & 1 & 0.4 & 0.6 & 0.3 \\ 0.1 & 0.7 & 0.6 & 1 & 0.7 & 0.2 \\ 0.9 & 0.8 & 0.5 & 0.3 & 1 & 0.7 \\ 0.8 & 0.7 & 0.4 & 0.7 & 0.7 & 1 \end{pmatrix}, \quad B = \begin{pmatrix} 0.5 & 0 & 0.4 & -0.2 & 0.1 \\ 0.7 & 0 & 0.1 & -0.3 & 0.6 \\ 0.3 & 0 & 0.5 & -0.3 & 0.8 \\ 0.4 & 0.3 & 0.4 & -0.1 & 0.2 \\ 0.3 & 0.6 & 0 & -0.8 & 0.7 \\ 0.3 & 0.5 & 0 & -0.7 & 0.7 \end{pmatrix}$$

Maximum eigenvalue of matrix *A* $\lambda_{\max} = 3.732$, which indicates a high ability of the system under consideration for self-development.

The level of competence will be assessed in some arbitrary units, which allow us to evaluate the dynamics of these indicators over time. In this case, the zero value $S_i = 0, (i = 1,2,\dots,6)$ indicates a lack of relevant competence, and negative values indicate a negative attitude of students to this factor.

Let us set the initial state of the competence vector in the following form

$$S_0 = [0.1 \quad 0 \quad 0 \quad 0 \quad -0.1 \quad -0.1]^T \cdot$$

Table 3. Educational system management scenario

Control Factors	Semester numbers							
	1	2	3	4	5	6	7	8
U_1 - Qualification of teachers	0.1	0	0	0	0	0	0	0
U_2-Educational and methodological support	0.1	0	0	0	0	0	0	0
U_3 - Hardware and software	0	0	0	0	0	0.1	0	0
U_4 - Living conditions	0	0	0	0	-0.1	0	0	0
U5 - Pre-University Education	0	0	0	-0.1	0	0	0	0

The level of control actions will be evaluated in relative units, lying in the range from -1 to +1. In this case, the positive value of the factor $U_k (k = 1,2,\dots,5)$ indicates its positive impact on competence levels, a negative value indicates - a negative impact of this factor, and zero - indicates a slight or no effect.

The system control scenario is given as a set of vectors of control actions in each semester of the educational process (Table 3).

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The results of modeling the dynamics of competence indicators according to formulas (6), (7) are shown in Table 4.

Table 4. Growth dynamics of universal competencies

Managed factors	Semester numbers							
	1	2	3	4	5	6	7	8
S_1 - Ability to work in a team	0.05	0.09	0.26	0.89	3.02	11.9	44.45	165.8
S_2 - Ability to build oral and written speech	0.09	0.1	0.29	1.04	3.96	14.80	55.42	206.83
S_3 - Foreign Language Proficiency	0.04	0.04	0.23	0.83	3.26	12.35	46.06	171.92
S_4-Ability to work with documents	0	0.04	0.23	0.88	3.24	12.26	45.77	170.87
S_5 - Motivation for learning	0.01	0.10	0.34	1.15	4.35	16.10	60.01	233.88
S_6 - Social adaptation	0	0.08	0.33	1.16	4.42	16.37	61.09	227.91

We see that due to the high ability of the modeled system for self-development, which was determined by experts when compiling a cognitive map, competencies grow at a high rate with minimal control actions, especially in the last semesters. This corresponds to the real state of affairs, since the specialist is especially intensively formed precisely in the last years of training.

6.2. Model for the growth of professional competencies

Let us turn to the cognitive map of professional competencies according to the methodology discussed above.

As control factors, we will leave the same ones that were chosen in the previous example.

Controlled factors in accordance with table 3 are selected as follows:

S_1 - Design and technological activities

S_2 - Research activities

S_3 - Scientific and pedagogical activity

S_4 - Motivation for learning

Representing the matrix of mutual influences of factors W_{pk} (Table 3) in block form in accordance with formulas (2) and (3), we obtain matrices A and B:

$$A = \begin{pmatrix} 1 & 0 & -1 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 \end{pmatrix}, \qquad B = \begin{pmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Maximum eigenvalue of matrix A $\lambda_{\max} = 1$, which indicates the inability of the system under consideration to self-development.

Let us set the initial state of the competence vector in the following form

$$S_0 = \begin{bmatrix} 0 & 0.1 & 0.5 & 0 \end{bmatrix}^T.$$

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Table 5. Educational system management scenario

Control Factors	Semester numbers							
	1	2	3	4	5	6	7	8
U_1 - Qualification of teachers	1	1	1	1	1	1	1	1
U_2-Educational and methodological support	1	1	1	1	1	1	1	1
U_3 - Hardware and software	1	1	1	1	1	1	1	1
U_4 - Living conditions	1	0	0	0	0	0	0	0
U_5 - Pre-University Education	1	0	0	0	0	0	0	0

The system control scenario is given as a set of control action vectors $U_i(t)$ in each semester of the educational process (see Table 5).

The results of modeling the dynamics of competence indicators according to formulas (6), (7) are shown in Table 6.

Table 6. Growth dynamics of professional competencies

Managed factors	Semester numbers							
	1	2	3	4	5	6	7	8
S_1 - Design and technological activities	2.5	3.5	7	16	33.5	62.5	106	167
S_2 - Research activities	4.1	7.1	10.1	13.1	16.1	19.1	22.1	25.1
S_3 - Scientific and pedagogical activity	4.5	7.5	10.5	13.5	16.5	19.5	22.5	25.5
S_4 - Motivation for learning	2.5	8	16.5	28	42.5	60	80.5	104

In this example, to obtain the values of controlled factors comparable with the previous example in order of magnitude, the maximum possible control actions were required (Table 3), which confirms the conclusion that the system is incapable of self-development.

It should be noted that in both examples the picture of the growth of competencies is qualitatively similar to the data in Tables 1 and 2.

7. Conclusion

The theory of management of the educational process considered in this paper in order to ensure the required level of trainees' competence is based on the use of the requirements of third-generation state educational standards and expert knowledge of specialists, designed in the form of cognitive maps. This work lies within the framework of the activities to create the National Qualifications System (NSC).

The use of cognitive maps makes it possible to assess the relationship between the most important factors of the educational process, identify among them the governing and controlled ones, and build a dynamic model of the control system that allows solving both the tasks of stabilizing the level of the educational system and the tasks of its transition to a new, higher level. At the same time, the key condition for successful modeling is the quality of cognitive maps, i.e. the qualification of experts who are able to assess the real relationship between the factors of the educational process.

It is proposed to use the dynamics of the number of universal and professional competencies mentioned in the working curricula as a target criterion in the management system.

In the future, it is required to conduct research on linking the proposed solutions to professional standards and other educational systems.

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