



Educational systems' cognitive management concepts

Los conceptos de la gestión cognitiva de los sistemas educativos

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ABSTRACT:

The paper purpose is to develop mechanisms for managing educational systems, as a complex, weakly formalized system with active subjects of management. The authors consider the educational system from the point of view of cognitive management built on the transformation of implicit information about the state of a multidimensional system into explicit knowledge that facilitates the adoption of managerial decisions for all types of education management (system, structure, process). The authors describe the possibilities of cognitive management in educational systems of different levels, taking into account its high activity. A model of the student as an active subject of pedagogical management was developed. The paper is intended for researchers, employees of educational management structures.

Keywords: the educational system, cognitive management, cognitive modeling, pedagogical management, active subject, management decision-making

RESUMEN:

El objetivo del artículo es desarrollar mecanismos para gestionar los sistemas educativos como un sistema complejo con sujetos activos de gestión. Los autores estudian el sistema educativo desde el punto de vista de la gestión cognitiva basada en la transformación de la información implícita sobre el estado del sistema multidimensional en el conocimiento explícito, que facilita la adopción de decisiones de gestión para todo tipo de gestión educativa (sistema, estructura, proceso). Los autores describen las posibilidades de la gestión cognitiva en los sistemas educativos de diferentes niveles, teniendo en cuenta su alta actividad. Se ha elaborado un modelo que presenta al alumno como sujeto activo de la gestión pedagógica. Además, se ofrecen los modelos cognitivos de varias situaciones educativas construidas conforme con las condiciones no estacionarias de la implementación de las actividades educativas. Estas situaciones contribuyen a la determinación de las acciones de control necesarias.

Palabras clave: sistema educativo, gestión cognitiva, modelado cognitivo, gestión pedagógica, sujeto activo, toma de decisiones de gestión

1. Introduction

Modern education is characterized primarily by its importance for any state, since it plays the main role in the formation of events, trends, and persons of "tomorrow day". The main capital and resource, for all the seeming technological sophistication of the world, is a person, his development, and potential, cultural expediency. This orientation contributes to a change in attitudes towards all types of education on the part of society (Dushina & Lutoshliva, 2009). At the same time, relatively new educational trends, such as humanitarization, individualization, diversification, standardization, etc., changed the state of education as a system, increasing its activity, instability, and variability.

In these conditions, there are natural contradictions inherent in all world educational systems (Levina, 2017):

- "Quality-accessibility";
- "Massiveness - efficiency";
- "Universalization - the loss of traditions";
- "Socialization - education", etc.

In addition to these contradictions, there is also an "information problem" in education that arose in connection with the almost full informatization of our lives: the changing of relations and roles in the traditional system of educational and pedagogical interactions. The same factor determines the need for the most effective use of all available information resources in a timely response to changes in the external environment and the requirements for the results of the education system. Such problems are complex, weakly formalized scientific and economic-technical problems that do not have trivial solutions. It can be confidently asserted that in addition to the known - organizational, program, technical and other types of support for the management of education, it is necessary to introduce new types of provision - information and intellectual.

Earlier, we considered the functions, tasks and ways of creating information management of education, which is a systematic presentation of timely, reliable, complete and systematized information about the state and possible development of processes, organization and the entire education system as a whole (Levina et al., 2015; Levina et al., 2016; Levina et al., 2017). Obviously, information flows become a resource for the development of the system when there is a single system for selecting, analyzing and managing metadata with certain information qualities, their automated circulation and the content updating on the basis of event analysis (Rosenberg & Tsvetkov, 2010).

The mechanism for making managerial decisions based on the information received (within the education system) requires disclosure because it uses "implicit knowledge in the form of human experience" (Sigov & Tsvetkov, 2015a,b). The way to solve the task is seen in the application of cognitive management in educational systems, as the formation of managerial decisions and actions based on the "intellectual process of solving problems that cannot be reduced solely to rational choice ... but based on the cognitive capabilities of management subjects " (Avdeeva et al., 2007). This type of management requires the construction of cognitive models, their analysis and the formation of cause and effect representations of processes and situations.

2. Methodology

2.1. Active approach as a property of the educational system

Active ones in the management theory are systems that have their own independent goal-setting system, the reflexing of actions and the possibility of a response to the control object (Burkov, Novikov & Cherkashin, 1998). It is noted that a system that includes people or groups

of people is naturally active one (Lutsenko & Napriyev, 2007; Levina et al., 2017). Indeed, the system of education at every level (the system in the most general sense, in the scale of the country, the level of education: preschool, school, vocational, higher, as a system; educational organization as a system) has a heterogeneity in the response to the control effect caused by the ability, readiness to perceive pedagogical and organizational management.

In the most general case, one can give an example of a learner who perceives new information for him. The teacher forms the information space and gives tasks that contribute to the acquisition of knowledge and the appropriation of abilities, skills, and competencies. The created system of tasks (planning) proposed for consideration is a management message (action), then, on the part of the teacher, other elements of management are included: analysis of the assignment, monitoring and correcting the student's actions (if necessary). This management cycle, obviously, can be violated at any stage by the student's reaction to the action (failure to complete a task) caused by various reasons (inability to solve the task, including psychological barriers, the absence of the desire to fulfill it (lack of motivation, self-management), etc.). Failure to complete one task or their system, without correction by the teacher, in turn, entails a violation of the training plan on the topic or subject, leaving problems in the informational field of the subject area, and, consequently, as a result of training – in competencies.

The active nature of management subject, therefore, requires the inclusion of adaptive mechanisms in the management of educational systems, structures, and processes. At the same time, researchers also note another factor – the expedient behavior of active systems (Lutsenko & Napriyev, 2007; Levina, 2016), that is, the reaction of the system controlled active elements is determined by the behavior or action of the learner as a managed object within the specified goal (desirable and not desirable system state, otherwise – the opportunities and problems of governance (Levina et al., 2017).

We believe that the student, as a subject of pedagogical management and an active element of the system, can be represented as a nonlinear superposition of subsystems (Fig. 1).

Figure 1

Model of the learner as an active subject of management

1 level	Emotional subsystem	Intellectual Subsystem	Information subsystem	Physical subsystem
Level 2	A subsystem for processing new educational information		Subsystem of interactions with the environment	
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓				
SELF-GOVERNMENT, SELF-REGULATION, ASSIGNMENT OF KNOWLEDGE AND SKILLS, FORMATION OF COMPETENCIES				
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓				
The result of pedagogical management			Capabilities (target state)	
			Problems (undesirable states)	

It should be noted that the result of pedagogical management (opportunities and problems) is considered from the point of view of management, from the perspective of pedagogical management subject, the undesirable states are probably can be targeted ones (for example, the learner considers the level of competence as sufficient for himself, and the teacher, relatively requirements of the educational standard – doesn't think so). The transition of pedagogical management's active subject quantitative changes into qualitative ones, that is, the appropriation and transformation of training information by learners, the formation by them due to the experience of certain actions, skills and competencies destroys the adequacy of the current model, as the results obtained of one management cycle transform the initial coordinates of the system - the information subsystem to a greater extent, the rest ones (emotional, intellectual, physical) – to the least extent. The changed characteristics can both change and not change the information processing and decision-making subsystems, both qualitatively and quantitatively. Thus, at the next iteration cycle of pedagogical management (Levina, 2017), we (perhaps) have a system different from the original one, which significantly complicates the mechanisms of pedagogical management, moving them towards the self-government.

E.V. Lutsenko & I.L. Napriyev (2007) emphasize that in this case, it makes sense to talk about reflexive control and reflexive adaptive control models. We believe that reflexing in the context of pedagogical management is manifested in the implementation of the typical management cycle's final stages (analysis-correction) from the point of view of the student learning activity's required and real results correlating, taking into account its capabilities, that is, it is just about cognitive management at all its levels - management of the system, structure, process.

2.2. Cognitive management in educational systems

The features of educational systems that we distinguished earlier, distinguishing it from other systems (variability, the complexity of formalization, activity of management subjects, etc.) (Levina, 2017) completely correlate with defined by V.Ya. Tsvetkov, I.V. Solovjov (2016) characteristics of a complex organizational and technical active system, which allows you to operate with normative, computer, heuristic and organizational technologies in the operational, information, functional-information and cognitive management spaces.

The specificity of educational systems can thus be described by a combination of the following provisions:

- 1) The variability of the structure and the functions performed, that is, the structure of the education system (qualitative composition) can vary, like its functions. For example, in the social context, it is not so important to achieve a competitive level of competencies for each trainee, as the acquisition of a socially adapted and active member of society, and in the personal context - on the contrary. This is connected not only with time (as for organizational and technical systems) but also with the type of management, external changes in the environment, the projection of state policy on the education system.
- 2) Incomplete correspondence of goals matrix to changing situations, which is emphasized by the multidimensionality of relations in the education system within the subjective-subject characteristics of all types of management and its current states, variable goals from the positions of each element of the active system (students).
- 3) The use of predominantly qualitative methods for analyzing management information, the inadequacy of quantitative descriptions, incomplete information about external and internal conditions for the implementation of the functions of the education system leads to incomplete information and misalignment of management objectives and methods, and a decrease in the development potential of the system.

Cognitive management is a management based on problem knowledge, i.e. information needed to identify and solve problems of social organization (Franchuk, 2003). The obtained reliable knowledge reduces uncertainty and reduces the risk of making wrong management decisions.

Specialists in the field of cognitive management V.Ya. Tsvetkov (2014), I.V. Solovjov, V.A. Mordvinov & O.S. Zhigalov (2015), etc. emphasize the need to use the information space as an "environment for the integration of cognitive management", the creation of a generalized information model (Tsvetkov, 2014; Levina, 2017). The methodology of the information approach to the management of educational systems extended by E.Yu. Levina (2017) made it possible to get an idea of the possibilities and results of information management, to design the information management system of education for the selected typology and to provide quantitative information on the course of educational activity. The result of the work of such a system is a structured set of data on the state of the system or the progress of educational processes for making managerial decisions.

3. Results

3.1. Stages of cognitive analysis of educational processes information models

The cognitive analysis consists of several stages, each of which implements a specific task. The consistent solution of these problems leads to the achievement of the main goal of cognitive management of obtaining reliable data for the management decision, which is facilitated by the construction of the cognitive model and the application of formal methods of analysis.

The *first step* in the cognitive analysis is the construction of a model of the information situation

and the information position of the management object, taking into account weakly structured factors. As an example, let us take the level of pedagogical management and a typical situation: the mastering of discipline topic by a group of students (for example, university students). Obviously, there are several components of the system: active (teacher, trainees) and not active (teaching material, pedagogical technologies), communication between them is realized through pedagogical interactions

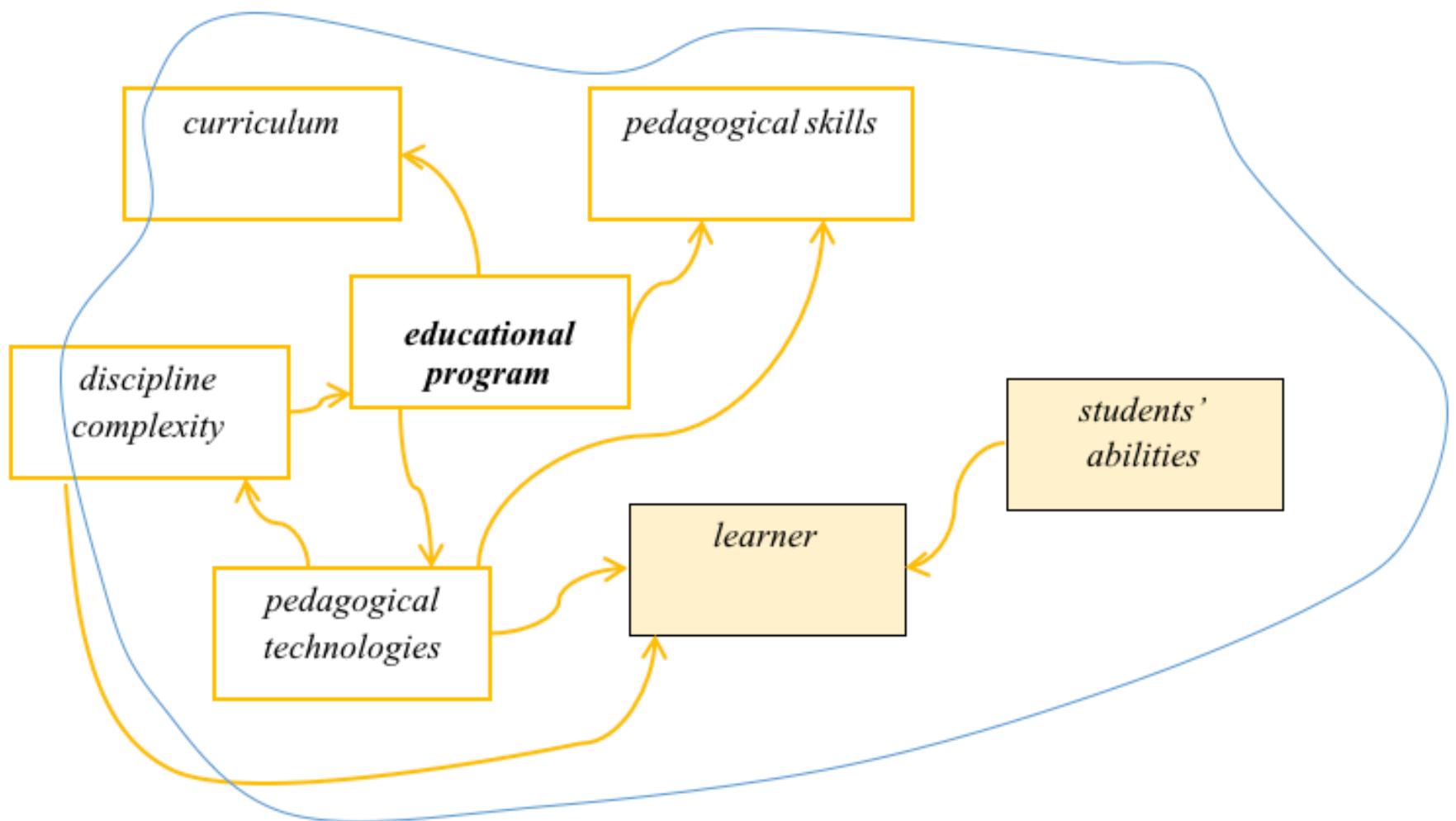
At the *second step* of the analysis, the dominant factors in the development of the situation are singled out, characterizing not the usual stationary but the problem situation, the development of the system (environment). It is important to note that anyway out of the educational process variability is fixed both in the positive direction (the possibility of development) and in the negative (correction until the "normal" result). As a norm will be considered the achievement of competencies' satisfied level established by the educational program of the discipline.

For our example, the problem of the educational situation posed may be: "teacher training", "trainee abilities", "learning disability", "training level of students", "violation of pedagogical technologies", etc.

At the *third stage*, the directions of the factors influence on each other are established. The connection is positive if the increase in one factor leads to an increase (positive increment, development) of the other; the connection is negative if an increase in one factor leads to a decrease in the other. Further here, a cognitive map is constructed in the form of interaction of process factors (Fig. 2).

Figure 2

An example of the educational process element cognitive map



The *fourth stage* involves the formalization of the processes' information descriptions. We set the value of the scale by the correspondence: 0 - no influence, 1 - weak influence, 2 - moderate influence, 3 - significant influence, 4 - strong influence, 5 - maximum influence.

Let's define for example several interrelations, considering that the result of the process is the quality of vocational training of students in the university (Table 1).

Table 1

Fragment of weights matrix of the educational process element (without factors of weak influence)

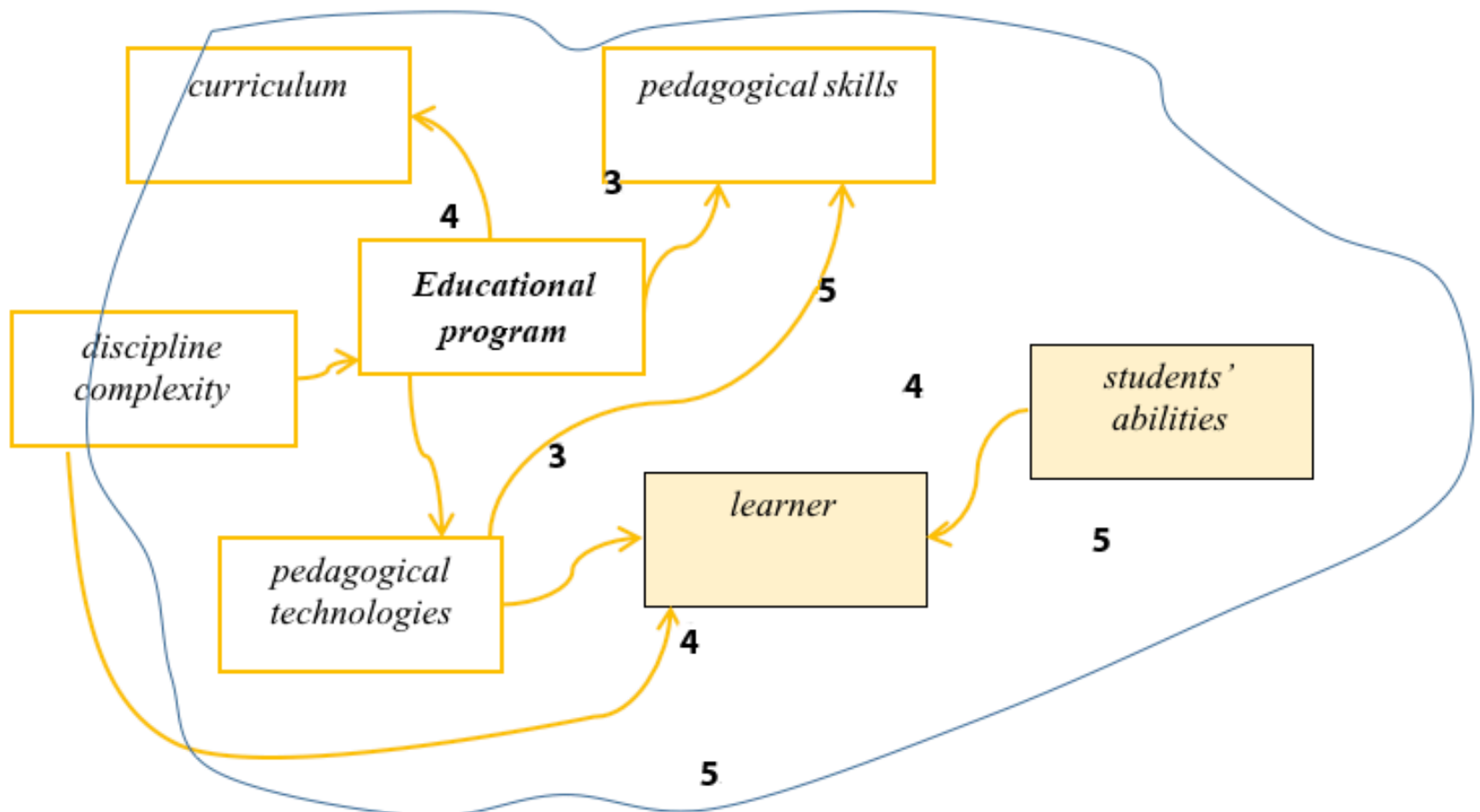
<i>Factor type</i>	<i>name of a factor</i>			
target factor	<i>The educational program</i>			
the factor of management	<i>pedagogical skills</i>	<i>discipline complexity</i>	<i>pedagogical technologies</i>	<i>curriculum</i>
factor weight	5	4	3	3
the influence factor	<i>learner</i>			

The next, the *fifth stage* involves evaluating the influence of different factors on the basis of comparative methods (analysis of hierarchies or non-transitive theory of preferences). We consider the objective one the classification of G.V. Sirotkin (2015), who identified the basic, target, redundant, external and internal factors in the structure of relationships.

At the *sixth stage* of the analysis, a cognitive map is constructed in the form of an oriented graph on the basis of the data obtained in the previous stages. Since in this study we select only the elements of the educational process, it is obvious that the resulting oriented graph is a limited example of cognitive data representation possibilities (Fig. 3).

Figure 3

An example of the functional graph of the educational process element (without factors of weak influence)



The seventh stage involves checking the adequacy of the situation cognitive model (verification) with respect to the assigned control tasks and, if necessary, its correction.

Practical application of the cognitive model allows us visually to track possible scenarios for the development of the situation (system), the detection of ways, mechanisms for influencing the situation in order to achieve the desired results, to prevent undesirable consequences. Its

functional description makes it possible to integrate the obtained detailed cognitive models into the information management system of the university and to model the educational activity on real data. The obtained control information will allow supporting the adoption of managerial decisions, to build an optimal management strategy, to set the target, desired directions and changes in the processes in the situation.

4. Discussion and Conclusion

The cognitive approach in management is realized in the management field of development of weakly structured objects, systems, situations. The development, verification and application of cognitive models increase the validity of management decisions in a complex, multifactor and variable environment. In general, cognitive modeling allows: to predict the consequences of various management decisions; to develop optimal management strategies in a rapidly changing environment, taking into account the impact of external, internal, difficult to predict, short-term, long-term and other types of trends and factors (Lutsenko, 2002; Gorelova & Radchenko, 2003; Prangishvili, 2005; Kulinich, 2010).

The application of cognitive modeling in education was considered by a number of researchers (Babakov, 2014; Tymchenko, 2014; Sirotkin, 2013, etc.). They considered as modeling issues at the level of management of the educational organization and management of education quality in the university as a whole. Many researchers note the following problems of constructing a cognitive model: difficulties are caused by the identification of factors; identification of significant and minor factors; ranking factors; revealing the degree of mutual influence of factors and using a variety of analysis methods to refine them. When modeling the educational sphere, it is obvious that such factors become even more, and in order to detect them, to reveal connections and clarify the parameters of mutual influences, it is necessary to use psychological diagnostic techniques.

One of the most promising areas of modern management thought is the orientation toward solving emerging problems based on knowledge. After all, knowledge is, first of all, information that allows solving problems. Huge data flows on the functioning of complex social systems are difficult to structure and use in order to manage and reduce the entropy of the system. We have an idea of the educational system as a system that has a complete necessary set of information on conditions of high turbulence. At the same time, the flow of information, in our opinion, can be transformed into information support of management, if we find the basis ("common denominator"). In our opinion, pedagogical information obtained through the application of standard procedures for monitoring students' knowledge demonstrates the specificity of educational activity: the ability and readiness of the student, the adequacy of pedagogical technologies, the organization of educational activities, the professional characteristics of the teacher, the characteristics of the educational environment, etc.; part of the information about the personal characteristics of students can be obtained and with the help of psych diagnostic techniques. Despite the fact that this attitude is possible with substantial assumptions, we have proved its applicability, at least to the management of education quality in the university.

The information we received and processed was analyzed by us with the help of adapted mathematical methods and a specially developed information management system of the university and was provided to the management structures of the University for Decision-making. However, because of its multidimensionality, despite the importance of information, its application outside the pedagogical experiment is significantly hampered and insufficiently transparent. Continuation of the study is the use of cognitive management, built on the basis of knowledge in conjunction with external and internal experience. We developed tools that meet the needs of cognitive management function and can be adapted to its goals. The main support of cognitive management can be the knowledge bases - systems of effective knowledge flows, maintaining the safety and relevance of knowledge.

An essential achievement of this study is its detailed description of education active subject -

the learner. In addition, the authors expanded the notion of not only cognitive models but also about the possibilities of implementing qualitatively new management methods within the university information management system at all levels of government.

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