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# APPLICATION OF THE COGNITIVE APPROACH IN THE FIELD OF PROJECT MANAGEMENT

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*The article describes the principles and methods of the cognitive approach to project management. The cognitive analysis and its content are dissected. The essence of cognitive system is considered, and as the cognitive model the example of cognitive map, the methodology of its construction and application is presented and described. The proposed approach allows an expert in a particular subject area to develop the most effective management strategy, based on his experience and, most importantly, on the ordered and verified knowledge of the managed object.*

## Introduction

Many approaches and methods are used to build modern information systems. In recent years, the cognitive approach, which is understood as the solution of traditional research science problems by methods that take into account cognitive aspects in the processes of perception, thinking, cognition, explanation and understanding, has been actively developed. This approach emphasizes the processes of knowledge representation, its storage, processing, interpretation, and creation of new knowledge.

Nowadays, obtaining reliable information and its operational analysis is the basis for successful management. This is especially relevant if the object of management and its external environment is a complex of complex processes and factors that have a significant influence on each other [1]. Nowadays it is important to use soft management of complex intelligent projects, the essence of which lies in the ways of self-management and self-control. Weak, the so-called resonance phenomena, are extremely effective for self-management, because they meet the internal tendencies of development of complex projects and programs. The main problem is how to push the project to one of its own and favorable paths of development, how to ensure self-management and self-sustaining development by a small resonant influence. One of the most productive solutions to the problems that arise in project and organizational management is the application of cognitive management. The basis of cognitive management is cognitive analysis, cognitive models, cognitive modeling, and cognitive system.

## Cognitive analysis

Initially, cognitive analysis was formed within the framework of social psychology, namely cognitivism, which studies the processes of perception and cognition. The application of social psychology's developments to management theory led to the formation of a special field of knowledge, cognitology, which focuses on the study of management and decision-making problems. At present, the methodology of cognitive modeling is being developed in the direction of improving the apparatus of analysis and modeling of situations. Theoretical achievements of cognitive analysis became the basis for creating computer systems aimed at solving applied tasks in the sphere of management.

Examples of cognitive analysis are PEST and SWOT analyses. They are used in strategic management [1]. For example, PEST-analysis (Policy, Economy, Society, Society, Technology), with the help of which the state of the resource is most often determined by the listed subsystems; SWOT-analysis (Strengths – pluses, that is, due to which the studied system can exist; Weakness – minuses, weaknesses; Opportunities – system opportunities; Threats – dangers and threats to the system existence). Similar methodologies of strategic analysis are currently used in UN commissions, for example, when selecting indicators for assessing the sustainable development of territories, states, and cities. Using knowledge about the object, groups of experts analyze the situation in the territory, choose oriented indicators and appropriate initiatives to prevent unfavorable development of this or that scenario. The models of the object under study are most often offered to experts in advance. They (models) create a kind of «framework» and are weakly structured – conceptual, that is, cognitive.

Cognitive analysis is defined by I. V. Prangishvili [2] as «sequential cause-effect structuring of information about processes occurring in the areas under study...». Such processes are described by many factors interconnected by cause-effect chains «if..., then...». The cause-effect chain «if..., then...» in algebra of logic was called sequentia and was used in the practice of problem formalization. The most frequent problems are those of qualitative nature, i.e. cognitive problems. This is achieved by the above-mentioned chains «if..., then...».

Cognitive analysis is sometimes called «cognitive structuring» by researchers. Cognitive analysis is considered as one of the most powerful tools for studying unstable and weakly structured environment. It contributes to a better understanding of the existing problems in the environment, identifying contradictions and qualitative analysis of the processes taking place. The essence of cognitive (gnostic) modeling of the cognitive analysis key point is to reflect the most complex problems

and trends of system development in a simplified form in the model, to investigate possible scenarios of crisis situations, to find ways and conditions of their solution in a model situation. Cognitive analysis consists of several stages, each of which carries out a certain task. The sequential solution of these tasks leads to the achievement of the main goal of cognitive analysis.

## Cognitive modeling and the cognitive system

Cognitive modeling is designed to structure, analyze and make management decisions in complex and uncertain situations (geopolitical, domestic political, military, etc.), in the absence of quantitative or statistical information about what is happening in such situations. Cognitive modeling contributes to a better understanding of the problem situation, identification of contradictions and qualitative analysis of the system. The purpose of modeling is to form and refine a hypothesis about the functioning of the object under study, considered as a complex system consisting of separate, but still interconnected elements and subsystems.

To understand and analyze the behavior of a complex system, a structural diagram of the cause-effect relationships of the system elements is constructed. The analysis of these relationships is necessary to implement different process controls in the project.

Cognitive modeling allows in an express mode, in the shortest possible time at a qualitative level:

– to assess the situation and analyze the mutual influence of the acting factors determining the possible scenarios of situation development;

– to reveal the tendencies of the situation development and the real intentions of their participants;

– to develop a strategy for the use of trends in the political situation in the national interests of Ukraine;

– to determine possible mechanisms of interaction between participants of the situation to achieve its purposeful development for the benefit of Ukraine;

– to elaborate and ground the directions of situation management in favor of Ukraine;

– to determine possible options for the development of the situation, taking into account the consequences of major decisions, and to compare them.

The use of cognitive modeling technology allows to be proactive and not to bring potentially dangerous situations to threatening and conflict situations, and in the case of occurrence – to make rational decisions in favor of the subjects of Ukraine.

For tasks related to organizational systems, the problem of uncertainty in describing and modeling the functions of the participants is not methodological, but intrinsic to the very subject of research. Different formulations of the problem of situation management are possible, depending on the completeness of the information available to the participants about the situation and other participants, in particular to find resonance and synergistic effects, when the improvement of the situation when several participants affect it simultaneously is greater than the «union» of the positive effects from each of the participants separately.

Cognitive system is often associated with decision support systems (DSS) or the system of management support (ESS – Executive Support System) [3]. A cognitive system is a structured, logically described or formalized model of a «soft» (weakly structured) system proposed for cognitive analysis.

The construction of a cognitive system includes an analysis of the modes of its operation, an analysis of the environment in which it functions. External and internal characteristics of a cognitive system are distinguished. External characteristics characterize the characteristics of the environment. They are denoted by their vector $X = (x_1, x_2, \ldots, x_n)$. Internal characteristics characterize the characteristics of individual parts of the system, they are denoted by a vector $Z = (z_1, z_2, \ldots, z_r)$. The combination of external and internal parameters forms the input parameters. Values characterizing properties of a cognitive system are called input parameters. They are denoted by a vector $Y = (y_1, y_2, \ldots, y_t)$. Combinations expressing the dependence between input and output parameters are considered a mathematical description of a cognitive system:

$$Y = F(X, Z) \tag{1}$$

Expression (1) is a fuzzy relation between two sets of parameters $A = (X, Z)$ and $Y$.

The modified hierarchy method is often considered to be the main method for constructing a cognitive system. Each level of the hierarchy has its own models. Here is the algorithm of the complex hierarchical approach to building a cognitive system:

1. The number of hierarchy levels in the cognitive system is determined.

2. The main criteria of each level are defined.

3. Initial states of components of the cognitive system and input values of parameters determining initialization of events are established, initial value of modeling time $t = t_0$ is set.

4. Structural, heuristic, simulation, and evolutionary models are constructed.

5. The fuzzy condition scale is set and the simulation path is selected.

6. The logic of feasibility of all events at all levels of the hierarchy in the cognitive system is checked.

7. A list of events $L_C$ for which the initialization conditions are met is constructed.

8. If the list $L_C$ is empty, proceed to item 9. Otherwise, control is given to carry out the procedure of servicing the first event from $L_C$. The time of this event in the future is modified and removed from the list. Transition to item 6.

9. In the list of scheduled events, the event with the minimum initialization time is found and the time which belongs to this time is corrected.

10. The complex criterion of the whole cognitive system is determined.

11. The condition for completing the complex simulation is checked. If it is not satisfied, we proceed to step 6.

## Cognitive model

The notion of a cognitive model is interesting [4]. One of the most common cognitive models is the cognitive map.

It is used in cognitive modeling of complex situations. A cognitive map (cognition map) is a type of mathematical model represented by a graph and allows describing the subjective perception of a person or group of people of any complex object, problem, or system functioning [5, 9]. It is designed to reveal the structure of causal relationships between elements of a system, complex object, constituent problems, etc., and to assess the consequences occurring under the influence of influencing these elements or changing the nature of relationships. Let's consider conditional model of sales at the enterprise (fig. 1).

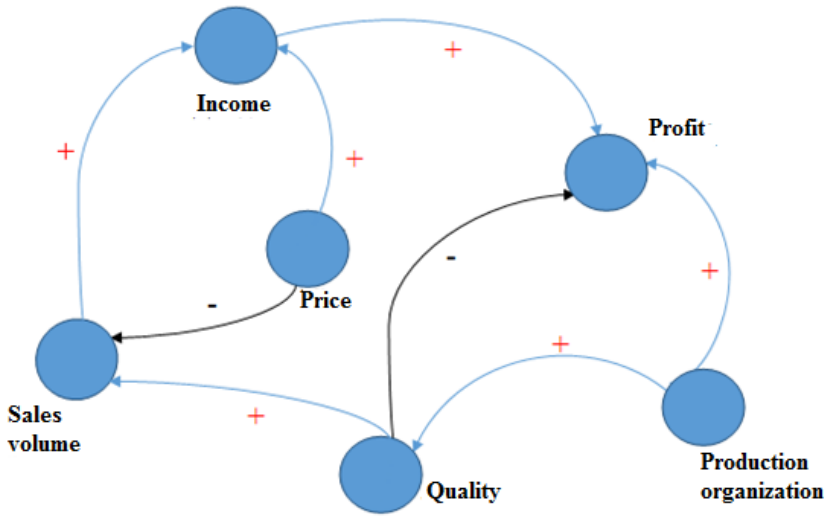


**Fig. 1.** Cognitive map of sales in a hypothetical enterprise

Here the nodes of the graph are the factors of the situation, and the arcs are the cause-effect relations between them. The plus sign on the arcs between the nodes-factors means that an increase in the value of the factor-cause leads to an increase in the factor-effect, and the minus sign means that an increase in the value of the factor-cause reduces the value of the factor-cause. The cognitive map reflects the functional structure of the situation being analyzed, as a change in the value of a situation factor results in a «front» of change in the values of the factors associated with it. This front of change is called an impulse process in the cognitive map and allows one to obtain predictions of the development of situations.

Let's consider the price-sales volume-income triangle. If you increase the price with a constant volume of sales (in units), the income goes up, it's arithmetic. It's the same when sales volume increases at the same price. But when the price goes up, the sales volume goes down, that's economics. What will be the total effect on income when the price changes? We have to weigh that effect somehow, that is, just the sign of the effect is not enough. To do this, let's first understand what the factors are measured in. Price, income, and profit are in hryvnias, and sales volume is in pieces.And what about the organization of production? You can say about it «it is at the top,» or «it leaves a lot to be desired». The same can be said about various factors of the outside world – «rush demand» or «goods are stale. Here already there are no natural quantitative measures, but it is possible to construct a qualitative scale. This is called «linguistic significance,» and a factor is then said to be a linguistic variable. All factors and, consequently, their changes have quantitative expression, this quantitative expression can be objectively measurable or have a linguistic value that has its own numerical interpretation. The interplay of factors reflected by cognitive maps is essentially a «weighted graph model of the system under study,» and this map is usually completed by a «cognitive analyst».

Consequently, the cognitive model includes a cognitive map (an oriented graph) and the weight of the graph arcs (an assessment of the mutual influence or influence of factors). In determining the weights of the arcs, the oriented graph is transformed into a functional graph.

Within the cognitive approach the terms «cognitive map» and «oriented graph» are often used as equivalent; although, frankly, the concept of oriented graph is broader, and the term «cognitive map» indicates only one of the applications of oriented graph. A cognitive map consists of factors (system elements) and connections between them [5, 10].

In order to understand and analyze the behavior of a complex system, a structural scheme of causal relationships between elements of the system (situation factors) is constructed. Two elements of the system A and B are depicted in the diagram as separate points (vertices) connected by an oriented arc, if the element A is connected to the element of causality: A → B, where: A is the cause, B is the effect.

Factors can influence each other, and such influence, as already mentioned, can be positive, when an increase (decrease) of one factor leads to an increase (decrease) of another factor, and negative, when an increase (decrease) of one factor leads to a decrease (increase) of another factor. And the influence can also have a variable sign depending on possible additional conditions.

The cognitive map displays only the fact that factors influence each other. It reflects neither the detailed nature of these actions, nor the dynamics of the configuration of actions depending on the configuration of the situation, nor the temporal configuration of the causes themselves. Consideration of all these circumstances requires a transition to the next level of information structurization, that is, the cognitive model of the information situation.

At this level, each relationship between the factors of the cognitive map is revealed by the corresponding dependencies, each of which can contain both quantitative (measurable) variables and qualitative (not measurable) variables.

As knowledge about the processes occurring in the situation under study accumulates, it becomes possible to reveal the nature of the connections between the factors in more detail.

There are the following difficulties in constructing a cognitive model: it is difficult to identify the causes; to isolate the essential and secondary factors; to rank the factors; to identify the degree of mutual influence of the factors.

The latter problem is most often solved by applying correlative analysis [6]. Selection of essential and secondary factors can be solved on the basis of the theory of advantages. Identification of factors is carried out on the basis of latent analysis.

Identification of essential factors is possible on the basis of impact analysis [7]. The use of cognitive models qualitatively increases the validity of making managerial decisions in a complex and rapidly changing environment, deprives the expert of «intuitive wandering», and saves time on comprehension and interpretation of events occurring in the system.

## Conclusions

The essence of cognitive project management is to help the expert develop the most effective management strategy based on his experience and, most importantly, on the ordered and verified knowledge about the management object [8]. The field of application of cognitive management is constantly expanding. First of all, it is decision-making in the development of states, territories, communities; modeling information wars and conflicts In the end, it is the task of information stability of systems, states, communities; families, as an average element of these groupings, and modeling human behavior as a complex organized biosystem. In our opinion, a promising direction is the development of entropic approach for the evaluation and structuring of information used in cognitive management.

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