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INTEGRATION OF KNOWLEDGE MANAGEMENT PROCESSES INTO A DYNAMIC ORGANIZATIONAL ENVIRONMENT

Abstract. The article is devoted to the study of the impact of intellectual resources in the form of knowledge bases on the sustainable development of organizations. In today's world, where Knowledge is a key resource for success, the integration of Knowledge Management becomes an important component to ensure organizational competitiveness. The study emphasizes that successful implementation of artificial intelligence and knowledge bases requires not only technological solutions but also cultural changes within organizations, particularly in the areas of learning culture and collaboration. The authors of the article investigate the processes of acquisition, combination, and protection of Knowledge as key components of organizational sustainable development. They point out that the ability to acquire and combine Knowledge allows organizations to realize their potential in value creation. Knowledge Management is presented as a strategic component aimed at increasing productivity and competitiveness. The article discusses higher-order capabilities, such as adaptability, absorptive capacity, and innovation capacity, which affect the ability of organizations to respond to changes in the external environment. The algorithm for Knowledge utilization in organizations describes a comprehensive intellectual platform for managing and optimizing processes in the dynamic organizational environment. The Knowledge Management system includes managed and managing components, where the managed system reflects current parameters and information, while the managing system provides data storage, learning, and ontological knowledge base. The ontological knowledge base includes a set of concepts, semantic relationships, interpretation function, and axioms. Knowledge base updates occur depending on changes in time and the addition of new concepts, relationships, and axioms. Generalized ER-diagrams illustrate the structure and interaction of the learning module with the results used to update the Knowledge base. The algorithm allows you to analyze the state of the system and make optimal decisions based on the accumulated Knowledge.

Keywords: Knowledge base, Knowledge utilization algorithm, ER diagram, ontology, aspects of sustainable development.

Introduction

In today's world, Knowledge is becoming a key resource and a key factor in the success of an organization, helping to make informed decisions and increase performance. An organizational culture focused on the generation, dissemination and application of Knowledge ensures the competitiveness of companies in a global environment. In this context, the integration of knowledge management becomes a strategic step for the sustainable development of organizations in the face of constant change.

The use of artificial intelligence and knowledge bases is an essential element of sustainable development strategies. They help companies adapt to changes in the business environment by ensuring efficient resource management, which contributes to the creation of sustainable and competitive organizations that can successfully operate in the face of uncertainty and change. Artificial intelligence and knowledge bases play a key role in helping organizations analyze large amounts of data, predict trends and risks, and make informed decisions. Based on a global survey of more than 3,000 managers and interviews with 17 executives [1], we found that artificial intelligence is being used to fundamentally revolutionize organizational performance, including through the implementation of knowledge bases. The effective use of artificial intelligence and knowledge bases allows an organization not only to respond to market changes but also to actively influence them, providing a competitive advantage in a dynamic environment. In addition, the integration of knowledge management processes contributes to the storage and systematization of information, which is an important aspect of sustainable development.

An important component of successful

implementation of knowledge bases is not only technological aspects, but also organizational culture. Companies should create a favorable environment for collecting, analyzing and utilizing knowledge. This includes developing staff skills, introducing open communication, and fostering innovation.

Problem Statement

In today's business environment, solving the problem of sustainable development of organizations requires effective knowledge management. There is a need to integrate intellectual resources in the form of knowledge bases. It is noted that the successful implementation of artificial intelligence and knowledge bases involves not only technological solutions, but also cultural transformations in organizations, including a culture of learning and collaboration. The main problem is the ability of organizations to collect, combine and protect knowledge to achieve competitiveness. Ineffective knowledge management limits the ability of organizations to create value and realize potential.

Analysis of recent research and publications

In today's dynamic world, organizations face constant change and challenges. In order to remain competitive and achieve sustainable development, they need to manage their Knowledge effectively. There are a number of challenges that organizations face when integrating Knowledge Management into a dynamic organizational environment, such as cultural barriers, lack of resources, and staff ineptitude. However, there are also many opportunities for successful integration of knowledge management, such as the use of new technologies, development of a learning culture and stimulation of collaboration, as demonstrated by the examples of IBM [2] and Nokia [3].

Integrating knowledge management processes into the dynamic environment of an organization to ensure sustainable development is a key aspect of modern business [4]. There are several approaches to integrating knowledge management into an organization, including the following:

– creating a culture of knowledge sharing;
– implementation of knowledge management technologies;
– developing new knowledge management processes and changing the organization's structure.

Publications in recent years have been actively exploring this topic, given the rapidly changing market conditions and technological innovations. Researchers identify the importance of adaptability of knowledge management in a changing environment and propose integration strategies aimed at sustainable development of the organization [5], justifying the need to use knowledge bases to automate learning processes [6]. In article [7], the authors propose to consider four key aspects of knowledge management: knowledge generation, knowledge sharing, knowledge application, and knowledge preservation.

Knowledge integration requires taking into account such key factors as the organization's culture, organization structure and available technologies [8], which directly affects the ability to achieve the goal of implementing knowledge bases in the dynamic environment of the organization. When planning the process of integrating a knowledge management system in an organization, it is necessary to provide for the presence of [9]:

– Management support: the organization's management must be committed to Knowledge Management and allocate resources to support it;
– Employee involvement: employees should be involved in knowledge management processes and understand the benefits;
– Effective communication: it is important to clearly define the goals and value of knowledge management and communicate them to all stakeholders;
– Measurement and Evaluation process: it is important to measure the impact of knowledge management on the organization by evaluating the effectiveness of the system.

Thus, integrating knowledge management into the dynamic environment of an organization can be challenging, but it can have a significant impact on the sustainable development of the organization [10].

The purpose of this article

The purpose of this article is to synthesize different approaches to defining dynamic capabilities and knowledge-based approaches into a single paradigm for ensuring sustainable development of organizations.

Achieving this goal involves the following tasks:

– analysis of the role of processes in organizations that provide information for the creation of Knowledge;

– research of opportunities based on Knowledge to increase the competitiveness of the organization;

– development of strategies to increase the focus on Knowledge and, accordingly, the competitiveness of the organization.

Summary of the main material

Today, most scholars in the field of strategic management are concerned with the fundamental question of how companies can achieve competitive advantages that enable sustainable development of the organization. Figure 1 shows a diagram of the influence of aspects on the ability of an organization to function in a dynamic environment [11].

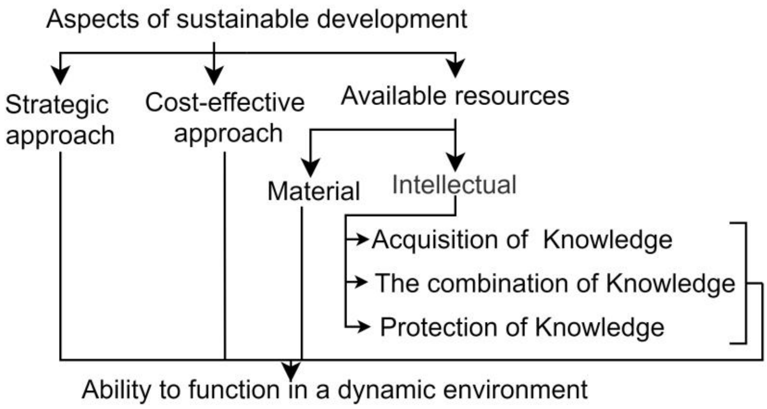

Fig. 1. Aspects of sustainable development

One of the main aspects affecting the possibility of sustainable development is the availability of "Intellectual" resources, which can be divided into three types:

– Obtaining Knowledge: creation of Knowledge, research of Knowledge, production of new Knowledge;

– Combination of Knowledge: combination of internal and external Knowledge [12];

– Knowledge protection: ensuring the security of organizational knowledge from improper and unintentional use [13].

The ability to acquire knowledge reflects the organizational readiness to introduce new concepts into its structure. This is achieved by facilitating the flow of information both within and outside the organization, as well as through innovative and improved methods of using existing knowledge. Initially, simple information is exchanged between departments. The full potential of the value of the acquired Knowledge is realized only when this knowledge is processed and utilized in the following stages.

Knowledge combination processes mainly depend on the relationship between new (acquired) knowledge and existing knowledge, as well as on experiments with innovative use of past experience. These processes contribute to the transformation of fragmented Knowledge located in different sources of the organization into a single Knowledge base useful for all users. The capabilities of the Knowledge Combining process help organizations realize their full potential in creating value from knowledge.

The capabilities of the knowledge combination process can create higher value only when knowledge resources remain rare and unique, including by creating opportunities for knowledge protection [13].

The ability to protect knowledge in an organization is to prevent misuse or theft by using various means, such as patents and copyrights, to preserve its uniqueness and value. Protecting organizational Knowledge includes restricting access to important information and making it difficult to imitate by making it secret and specific.

The idea of knowledge management is based on the fact that organizations are viewed as knowledge systems consisting of a number of well-planned processes aimed at obtaining knowledge. Knowledge management includes a set of processes aimed at effectively managing and utilizing organizational Knowledge to create value, improve productivity and gain competitive advantage in the marketplace. The main component of this concept is the processes and capabilities that actually form the basis of effective knowledge management. Thus, in order to effectively manage sustainability processes, an organization must create knowledge management capabilities.

Dynamic capabilities of an organization based on the use of knowledge bases can be viewed as the ability of an organization to achieve competitive advantage through the use of accumulated knowledge and the process of generating new knowledge. Among the higher-order capabilities are the following:

– adaptive capability is defined as the ability of an organization to effectively adapt and reorganize its resources in accordance with changes in the external environment [13];

– absorptive capacity is defined as the ability of an organization to identify, acquire and apply external knowledge;

– innovation capability is defined as the ability of an organization to use market opportunities through the introduction of new Knowledge.

Adaptability enables organizations to respond flexibly to changes in accordance with priorities and environmental conditions. The assessment of this capability is based on the match between resources and strategic needs. Adaptive companies are able to change quickly, which allows them to discard outdated approaches in favor of new ones. The ability to adapt can be market, technological or organizational, each of which has its own characteristics and requirements.

The ability to absorb is based on four key stages: gathering, understanding, transforming and using knowledge. Knowledge acquisition refers to the organization's ability to obtain relevant information from external sources, while comprehension involves perceiving, interpreting and understanding this information. Knowledge transformation involves adapting it to the needs of the organization, and utilization is the application of new knowledge for commercial benefit.

Innovations are manifested in the response of companies to changing external conditions by creating new mechanisms and processes, discovering new relationships and forming new combinations that can be combined under the concept of "new Knowledge". Their potential is manifested not only in tangible aspects but also in intangible ones, such as new competencies and the research and development atmosphere [15]. Knowledge affects the ability to innovate production, innovation processes and managerial innovation. The ability to innovate production includes evolutionary and revolutionary innovations, while process innovations are aimed at improving production or service processes.

Adaptive, absorptive and innovative capabilities are interrelated, but conceptually very different. The focus of adaptive capability is to align organizational resources with environmental factors. Absorptive capability emphasizes the importance of acquiring and integrating external knowledge with the organization's processes. Innovation capability aims to gain competitive advantage through new markets, products, or processes. Combining current and new Knowledge bases facilitates their use to solve problems and adapt to a dynamic competitive environment.

The algorithm for using Knowledge in an organization involves the iterative flow of information through processes and systems in the organization's dynamic environment. The system proposed in Figure 2 is a comprehensive intelligent platform aimed at managing and optimizing processes in a dynamic environment. The system in Figure 2 consists of two main components: a managed system and a control system.

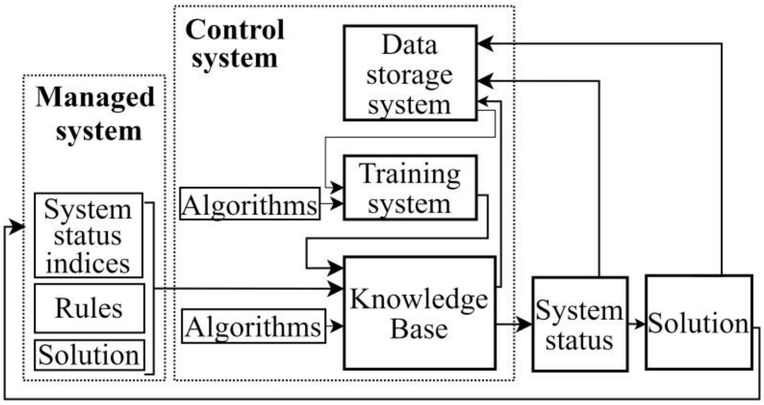

Fig. 2. Algorithm for using Knowledge

The managed system includes: system state indices that reflect current parameters and indicators; external information; rules and laws that define the logic and strategies of action; information about previous decisions and their consequences, which allow taking into account the historical context. The control system includes: a data storage system responsible for storing and updating information; a learning system that uses accumulated and external data to search for new Knowledge; an ontological Knowledge base that contains the results of data processing in the form of classified information about Knowledge. The state of the system is determined by analyzing indicators based on the accumulated Knowledge, which allows to obtain an objective picture of the situation. Decision-making is based on the analysis of the system state and the use of Knowledge to determine optimal strategies and solve tasks.

A generalized model of the ontology of the knowledge base of a certain subject area can be described as [16]:

$$O_t = \langle X_t, R_t, F_t, A_t \rangle, \qquad (1)$$

where X_t is a finite set of concepts; R_t is a set of semantic relations between concepts; F_t is a function of interpretation of concepts and relations; $A_t(D, R_s)$ is a set of axioms defined by a set of additional concepts D and restrictions of the scope R_s.

An ontological knowledge base stores information about a particular subject area in the form of a generalized ontology model consisting of four main elements: a set of concepts *X*, semantic relations *R*, an interpretation function *F*, and a set of axioms *A*.

Since the system is dynamic, its state depends on changes in time *t*, and the ontology of the Knowledge Base is updated accordingly:

$$O_{t+1} = \langle X_{t+1}, R_{t+1}, F_{t+1}, A_{t+1} \rangle, \qquad (2)$$

subject to

$$X_{t+1} = \left(X_t \cup \{x'\}\right) \oplus \left(X_t \setminus \{x'\}\right) \oplus X_t, \qquad (3)$$

$$R_{t+1} = \left(R_t \cup \{r'\}\right) \oplus \left(R_t \setminus \{r'\}\right) \oplus R_t, \qquad (4)$$

$$F_{t+1} = \left(F_t \cup \{f'\}\right) \oplus F_t, \qquad (5)$$

$$A_{t+1} = \left(A_t \cup \{A'\}\right) \oplus A_t, \qquad (6)$$

where $\{x'\}, \{r'\}, \{f'\}, \{A'\}$ are, respectively, new concepts, relations, functions of interpretation of concepts and relations, and axioms.

The generalized ER diagram for the ontological knowledge base (Figure 2) looks like this:

```
erDiagram
  Knowledgebase {
     string ID
     string Title
     text Description
     date CreatedAt
     date UpdatedAt
  }
  Knowledgebase||--||Feedback: receives
  Knowledgebase||--|{TextualInformation: contains
  Knowledgebase||--|{Ontology: uses
  TextualInformation {
     string ID
     string Content
     date RetrievedAt
     date ProcessedAt
     string JSONData
  }
  TextualInformation||--||MachineLearning: processed by
  MachineLearning{
     string ID
     string Algorithm
     string Parameters
     date ProcessedAt
     string JSONResult
  }
  Ontology {
     string ID
     string Concept
     string Definition
     string Relations
     string Domain
     string Range
  }
```

where *Knowledgebase* is the main entity containing all Knowledge, with fields for identifier, title, description, creation date, and update date; *Feedback* is feedback from the system or information about the availability of certain Knowledge; *TextualInformation* is a source of external textual information with fields for identifier, content, date of receipt, and date of processing; *MachineLearning* is a machine learning methods that process textual information and have fields for identifier, algorithm, parameters, processing date, and result in JSON format; *Ontology* is a ontological concepts with fields for identifier, concept, definition, relationship, scope, and range.

The generalized ER diagram for the module of training the knowledge base through a JSON request at the “Input” is as follows:

```
erDiagram
  InputData||--|{MachineLearningModule: sends
  InputData||--||Knowledgebase: updates
  MachineLearningModule{
     string InputText
     string Algorithm
     string Parameters
  }
  MachineLearningModule||--|{OutputData: returns
  OutputData{
     string ProcessedText
     string JSONResult
  }
```

The *MachineLearningModule* receives input data (*InputData*) and processes it using the specified algorithm and parameters. After processing, the module returns the result in the form of *OutputData*, which contains two fields: *ProcessedText* - the processed text, which can be the result of various operations such as classification, sentiment analysis, or extracting existing information and JSONResult - a structured result in JSON format that can contain more complex information such as classification labels, weights, probabilities, etc.

The generalized ER diagram for the training module of the Knowledge Base, which reflects the interaction between the training module and its result, i.e., the “Output”, and is the “Input” for the Knowledge Base, has the following form:

```
erDiagram
      MachineLearningModule||--|{
      OutputData: returns
      OutputData{
         string ProcessedText
         string JSONResult}
```

This diagram illustrates the process of processing input data by the learning module and generating its result in the form of processed text and a structured JSON object used to update the knowledge base according to the principle (2)-(6).

Consider a system that functions under

the influence of internal and external variables. These variables will be considered regulating, and as for the control mechanism, let's assume that it is formed on the basis of a signal that does not coincide in time with the moment of execution. The state of the system can be written in the form:

$$\dot{x} = A \cdot x + B \cdot u, \tag{7}$$

where $A = \{a_{ij}\}, B = \{b_i\}$ are a linearly independent matrix and vector; u is a control signal that has the form:

$$u = \sum_{i=1}^{n} c_i x_i (t - \tau), c_i, \tau > 0, c_i, \tau - \text{const.} \tag{8}$$

The system (7) is Lyapunov stable if for any deviation from the equilibrium state $\varepsilon > 0$ there exists $\delta > 0$ such that there exists for $\forall x_i \in X$:

$$\sum_{i=1}^{n} \|x_i\| < \delta, \tag{9}$$

where δ is the threshold of acceptability of deviations from the “ideal” state.

Accordingly, asymptotic stability is achieved at $\lim_{i \to \infty} \|x_i\| = 0.$

The functioning of system (7) (Figure 2) is aimed at ensuring the existence of a definite-positive function $V = V(X)$ for which:

$$u(x) = V(x_{i+1}) - u(x_i) \le -\omega(\|x_i\|), \forall x_i, \tag{10}$$

subject to

$$V(x_i) \le f(V(x_{i+1})), i = \overline{1,n}, \tag{11}$$

where ω is a definite positive function of a scalar argument; f is a continuously monotonically increasing function.

Given the above and (7)-(9), we can conclude that the control system (Figure 2) should be aimed at ensuring the stability of the Lyapunov equilibrium. The stability of the equilibrium is ensured by the following conditions:

– there is a definite positive function

$$V = V(X);$$

– there exists a continuous, monotonically increasing function f for which $f(0) = 0;$

– there exists a small number $\delta > 0$ for which:

$$f(V(x_{i+1})) \le \max\left\{V(x_{i-j}) \mid j = \overline{0, m+l}, l \in \square \right\},$$

subject to

$$\left\{x_g : \|x_g\| \le \delta \cap \left\{V(x_g) \le \min_{\|Z\|-\delta} \{V(Z)\}\right\}\right\}.$$

The system (Figure 2) and equation (7) can be written as follows:

$$\Delta(\lambda, \tau) = (-1)^n \cdot \left(p_n(\lambda) - \psi_{n-k}(p_n(\lambda))\right), \tag{12}$$

$$\psi_{n-k}(p_n(\lambda)) = \sum_{i=1}^{n} c_i \cdot e^{-\lambda\tau} \cdot p_{n-k}(\lambda), \tag{13}$$

$$\Delta(\lambda, \tau) = 0, \tag{14}$$

where $p_n(\lambda)$ are coefficients of the polynomial characterizing the matrix *A*, the degree of the polynomial $p_0(\lambda)$ is n_0.

Accordingly, the control signal u:

$$u = z(n) + p_1 \cdot z^{n-2} + \ldots + p_n \cdot z. \tag{15}$$

Investigating the effect of the number of control cycles on the time it takes for a system to return to equilibrium is key in engineering and control science. This allows us to better understand the dynamics of systems and optimize their characteristics to achieve faster stabilization.

As part of the research, we analyzed the impact of the feasibility of implementing the system (Figure 2) to improve the quality of system management.

The equilibrium state was chosen as the main quality criterion.

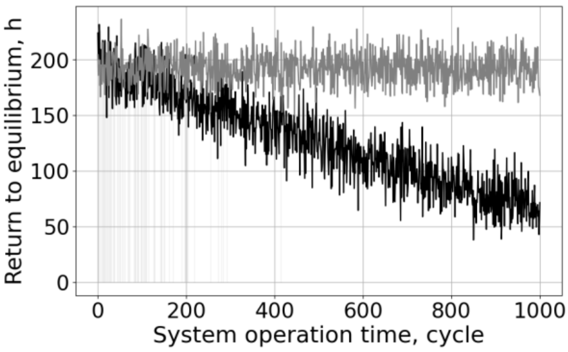

Fig. 3. Comparison of the time to return to equilibrium

Typically, with an increase in the number of control cycles, the time to return the system to equilibrium decreases. However, there are saturation points when additional cycles do not bring significant improvements, as evidenced by the system dynamics, without the introduction of the Knowledge Base - the gray line (Figure 3). In turn, the analysis of systems using the proposed algorithm for the production of knowledge bases (Figure 2) demonstrates a positive trend in reducing the time to return the system to equilibrium - the black line (Figure 3).

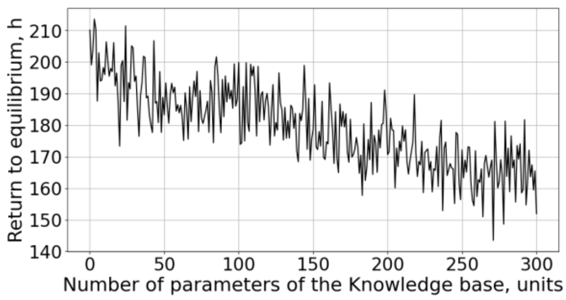

Fig. 4. Dependence of the number of parameters in the knowledge base on the speed of returning the system to equilibrium

As you can see from the graph (Figure 4), the time it takes for the system to return to equilibrium is influenced not only by the availability of the Knowledge Base, but also by its characteristics. For example, the number of parameters studied and stored in the Knowledge Base. The authors have studied a knowledge base with the number of parameters up to 300. Implementation of the Knowledge Base with almost 300 parameters allowed to reduce the time of returning the system to the state of equilibrium by 25 percent.

The authors also studied the impact of the size of the knowledge base on the quality of system management. To model the "quality of management" parameter, a synthetic parameter was chosen - the desired image of an ideal system, according to experts, taking into account the equilibrium parameter. The "ideal" system was defined as 1 (or 100% quality). For modeling, a system with a knowledge base containing 300 observed and studied parameters was selected.

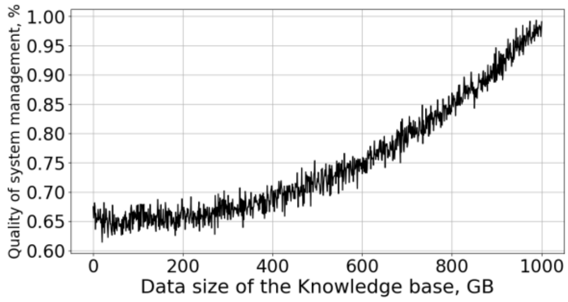

Fig. 5. The impact of the size of the knowledge base on the quality of system management

As can be seen from Figure 5, the growth of the Knowledge Base has a positive effect on the quality of system management. However, it should be noted that unlimited growth of the Knowledge Base can contribute to overtraining the system and have the opposite effect. In the current study, the authors did not have the opportunity to analyze the effectiveness of using systems with larger knowledge bases and more parameters. However, the current study demonstrates a positive trend in the growth of system management efficiency using the proposed model (Figure 2).

Conclusions

The use of knowledge bases in organizations opens up wide opportunities for achieving competitive advantage. The study demonstrates that the system of management and optimization of processes in the dynamic environment of an organization is based on the iterative movement of information, which can be a knowledge base.

The proposed algorithm provides a basis for the effective use of knowledge in organizations, which contributes to objective decision-making and strategy optimization.

The generalized model of the knowledge base, which is an integral component of the organization's knowledge management system, demonstrates the importance of structuring knowledge for its effective use.

Further research is needed on the impact of the number of parameters processed and stored in knowledge bases and research is needed on the optimal size of knowledge bases. This research can provide information on the balance between resource use and the expected effect of their use.

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