

“Information technologies for developing a company’s knowledge management system”

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INFORMATION TECHNOLOGIES FOR DEVELOPING A COMPANY'S KNOWLEDGE MANAGEMENT SYSTEM

Abstract

Escalating competition, technological changes and the struggle for innovation present companies with a knowledge management (KM) challenge. To implement it at the modern level, it is necessary to develop a knowledge management system (KMS). Significant opportunities for this are created by information technologies (IT), qualitatively changing approaches to knowledge management. Therefore, the study aims to clarify the theoretical foundations of shaping the company's KMS and conceptualize information tools for its formation.

Within the theoretical foundations of KM, its essence (as a systematic management activity and a set of measures to ensure the business processes of obtaining, storing, disseminating and using knowledge in the company), the subject (the aforementioned processes and various types of knowledge), and links with other types of management (innovation, information, personnel management, etc.) are specified. Given the main goals, principles and tasks of KM, its main approaches, key processes and control elements are summarized. The conceptual foundations of KMS development are formulated and its subsystems (methodological, planning, information, and functional subsystems for ensuring business processes for obtaining, distributing and using knowledge) are highlighted.

Given the importance of IT, the following concepts have been formulated: a portal for R&D management, innovation management platforms, and a tool for formalizing knowledge and corporate knowledge base. Their purpose, functionality, and the role of ensuring work with knowledge and KM implementation are described. The problem of their implementation, operation and improvement is emphasized. The research results allow creating a new technological basis for the introduction of knowledge management.

Keywords

knowledge, knowledge management, knowledge management system, information technology, portals, information tools

JEL Classification

D29, D80, M15

INTRODUCTION

The increase in the intellectual component of goods and services, the growth of knowledge-intensive production, as well as the paramount importance of knowledge for the creation and marketing of innovation have turned it into a strategic resource of any company. The availability of knowledge and the ability to effectively apply it have become critical characteristics of the maximizing firm. On the other hand, the modern economy is undergoing rapid market, technological and social changes, dominated by the innovative paradigm of competition, which requires the intensification of the processes of obtaining and using knowledge to ensure sustainable strategic development. Therefore, knowledge management (KM) has become an integral part of the activities of companies in various economic sectors. A wide range of tasks and components requires a systematic approach, which

is implemented by developing a knowledge management system (KMS) of a company. This requires a generalization of the relevant conceptual, theoretical and methodological foundations of KM, as well as practical experience in this area.

Companies that strive for consistency in KM, actively introduce modern information technologies (IT), create corporate portals, use special computer programs to work with knowledge, and create new services for training employees. However, the role of IT can be significantly enriched, become the basis for the formation of a better KMS, adding new opportunities to work with knowledge. Thus, the paper aims to improve the theoretical foundations of the KMS development and formulate proposals for expanding the role of IT, in particular, creating new information tools.

1. LITERATURE REVIEW

In the modern economy, the processes of obtaining (in particular, generating), disseminating and using (transforming into innovation) knowledge become critical. Due to the great importance of knowledge manifested in goods (services), culture, technology, and work efficiency (Crevoisier, 2015), companies are faced with the need to implement KM.

The principles of knowledge management have long been formed in management theory, which is confirmed, in particular, by the work of Drucker (1969). Theoretical and methodological foundations of KM originate from the concept of tacit knowledge (Polanyi, 1967), the theory of knowledge transformation (Nonaka & Takeuchi, 1995), the concepts of the learning organization (Pedler et al., 1994), the knowledge-based organization (Leon, 2018), and the theory of the knowledge-based firm (Grant, 1993). In parallel, the concepts of knowledge-based economy (Lundvall & Foray, 1996) and knowledge sharing economy (Helmstatder, 2003) developed. KM is primarily associated with information provision and staff training, but its broader understanding is needed.

Companies choose the ratio of knowledge sources: internal developments and/or external sources. Then, the knowledge that arises or enters the company is disseminated and mastered in it for further use in the development of innovations and other aspects of productivity (Grigoriou & Rothaermel, 2017). Communication is a prerequisite for this (Liyanage et al., 2009). The next stage is the transformation of knowledge into innovation (Akram et al., 2011).

KM plays a key role in ensuring all processes of obtaining, disseminating and applying knowledge

as a basis for innovation. KM methods, one way or another, are aimed at promoting effective innovation (Ode & Ayavoo, 2020), determine the speed and efficiency of innovation processes, as well as the quality of innovation. As a result, this forms the main contribution of KM to the company's overall productivity (Mardani et al., 2018). With this in mind, the potential for the generation, dissemination and use of knowledge is mandatory for the company. Its implementation requires appropriate planning, organization, control, coordination, etc., which is summarized in KM, which becomes strategically important. This also applies to KM in the framework of certain innovative projects, where knowledge is considered as a basic resource, and KM also focuses on observing time and money constraints (Polyaninova, 2011). This allows considering KM as a factor in increasing the productivity of projects, in particular, project culture.

In practice, the concept of a learning organization (firm) has become widespread, where KM is a basic component of management (Anjaria, 2020). Within the framework of this concept, a wide range of KM areas (receiving, processing and disseminating information, overcoming personnel resistance, conducting organizational training, etc.) is considered, which provides many tasks for the KM development.

In the context of innovation, KM encompasses actions related to minimizing the associated risks. The quality of KM determines the ability of companies to accept internal and external risks, in particular those related to knowledge. This is especially true for small and medium-sized enterprises (Hock-Doepgen et al., 2020). KM is also important for quality management and corpo-

rate sustainability as it mediates their relationship (Abbas, 2020).

The Fourth Industrial Revolution and digitalization are reshaping supply chains, leading to the accumulation of data that can be transformed into new knowledge and solutions that are valuable to companies. This expands the directions of KM and integrates it with supply chain (cost) management in order to optimize them (Schniederjans et al., 2020).

KM is a prerequisite for activities aimed developing and implementing environmental innovations (green technologies), allows the acceleration of their development and achievement of acceptable economic indicators. Due to the complex nature of environmental problems and requirements, a separate direction of KM is formed, such as obtaining (generating or acquiring) knowledge, sharing knowledge and using it in the relevant field (Abbas & Sağsan, 2019). The transition to sustainable development involves the intensification of business cooperation with universities as sources of knowledge and human capital, which is also within the competence of KM (Martins et al., 2019).

The globalization of the world economy has led to the development of international business, the activities of which are becoming increasingly complex in terms of both market actions and the development and promotion of innovation (Hill & Hult, 2011). Consequently, there is a need for KM: inclusion in international production and supply chains, global innovation networks, international relations in education and R&D, which requires a global approach. This applies not only to large international companies, but also to small and medium-sized businesses, especially innovative ones (Ferraris et al., 2019). In the context of the complexity of the business environment, KM is closely related to foresight, the use of predictive knowledge, and includes elements of planning (Bootz et al., 2019).

KM as a field of management is developing rapidly, its approaches are evolving, and new components and methods are emerging. This also applies to the creation of KMS, which began to be developed in the early 2000s (Jang et al., 2002). The emphasis was placed on the use of IT, reengineering

the processes related to KM. With the advent of IT, the mechanisms for obtaining, disseminating and processing knowledge began to transform. Analysis of best practices for knowledge management in companies (Ramasamy, 2011), corporate strategies, handbooks and programs on knowledge management (IBM, Samsung, Intel, Google, Microsoft, Ford Motor Company, etc.) confirms the emphasis on expanding the role of IT in solving KM problems.

IT has significantly influenced the functional content of KMS (Tseng, 2008), becoming the basis for design, production and marketing activities, communication with partners and consumers. Thus, IT integrated KM elements into the information infrastructure of companies, supporting all business processes and changing the organization of work in the company as a whole (Paschek et al., 2019). An example is the use of Building Information Modeling (BIM) technologies that provide parametric modeling, virtual visualization and a centralized platform (Wang & Meng, 2019). IT has also improved KM methodologies and tools. An example is the dissemination of knowledge maps, which encompass the definition, acquisition and description of knowledge, knowledge references and map formalization (Mengqi & Weiguo, 2019). In this context, the economic efficiency of the use of tools and resources to create new opportunities for KM are monitored (Lee et al., 2020).

The development of innovations determines the need for accumulation and integration of knowledge, since it is the stock of knowledge that determines the ability to synthesize and use new knowledge. Therefore, knowledge bases (KB) are an important element of KM in companies in various sectors of the economy. They are used to organize and support innovation processes, including open innovation (Aslesen & Freel, 2012). KBs serve as a form of accumulation and storage of knowledge, affect their recombination in various forms, contribute to the synthesis and dissemination of new knowledge in the company. KBs are seen as factors of innovativeness and competitiveness, especially in high-tech and creative industries (Hassink & Plum, 2014). However, despite the importance of KB, there is a lack of experience in their creation and role in knowledge management processes. Thus, the issue of KM is relevant and constantly expanding.

2. AIMS

The study aims to clarify the theoretical foundations for developing a company's KMS and to propose the concept of new information tools for its formation.

3. GENERALIZATION OF MAIN STATEMENTS

Justification of the KM foundations is based on the hypothesis of the systematic use of its elements by companies in various industries, as well as the need to achieve an integrated nature of KM, in particular through IT. The processes of generation, dissemination and use of knowledge are fundamental to companies in the modern economy and have their own characteristics. The content, organization of these processes and, accordingly, the role of IT in their provision require special research, so this study will consider them as part of KM.

For modern companies, effective work with knowledge and KM becomes benefits of the highest order and productivity factors. KM covers operations or work with knowledge, the processes of acquiring, disseminating and using it to ensure its effectiveness. This is relevant due to the growing cost of knowledge as part of activity and intellectual work.

The analysis allowed for singling out the following key definitions that characterize the KM essence:

- 1) a strategy for acquiring knowledge to improve efficiency;
- 2) identification and transformation of information, information flow management, organizational change and human resources;
- 3) a holistic approach to the effective use of experience to create a competitive advantage;
- 4) an integrated system of processes, practices and methods that allow employees to receive and exchange information;
- 5) analysis of available and necessary knowledge resources, further planning and control of re-

lated processes to achieve the goals of the organization; and

- 6) a systematic approach that allows optimal use of timely, accurate and relevant information in the organization, contributes to the discovery of knowledge and innovation, training, integration of various sources of information, individual and collective knowledge (John Girard & Joann Girard, 2015).

KM is proposed to be understood as:

- 1) a set of measures to organize and ensure the processes of obtaining, storing, disseminating and using knowledge, covering all management functions and creating special methods of work;
- 2) purposeful and systematic management activities, including the development of methods, techniques, procedures and tools for searching, obtaining, distributing, evaluating, storing and using knowledge and necessary intellectual resources.

KM applies not only to processes in the field of knowledge, but is carried out to improve the efficiency of all business processes of the company, that is, it is presented as an integrated function aimed at improving efficiency and achieving the company's goals, as well as an element of strategy and culture.

The subject of KM is the main processes of obtaining, disseminating and using knowledge in the company. This includes the use of human capital, intellectual resources and information tools. KM can focus on different types of knowledge in terms of content, form, purpose, novelty, value, method of origin. This includes both explicit knowledge, protected intellectual property and tacit knowledge (including values, attitudes, judgments), know-how, practices and solutions, which are knowledge that is largely hidden, distributed, not formalized and not protected, but they are decisive for the result. Organizational knowledge as a set of ideas about the work of a company, its structure and culture can be distinguished into a separate category. The interpretation of knowledge as a social construction also deserves separate view

(knowledge is created in social interactions; the subject of activity is not so much individuals as social groups; the acquisition and use of knowledge depends on collective strategies) (Jakubik, 2007).

KM is included in the implementation of the company's strategy and refers to strategic management (goals, company development strategy, which determines the need for knowledge; decision support); innovation management (ensuring R&D and innovation); investment management (investment in R&D, human capital, IT); information management (provision of information flows, communication, support of intellectual activity, infrastructure development); technological management (acquisition/development and implementation of new technologies; acquisition of know-how, creation of competencies); marketing management (study of markets and needs; study of the market environment; development of new products; product promotion); personnel management (adaptation, training and motiva-

tion of personnel; hiring specialists; organization of intellectual work; improving organizational culture; support for cooperation, transfer of experience); intangible assets (monitoring and assessment of assets in the global space; intellectual property protection); risks (assessment and management of innovation and knowledge development risks); and quality (product design and technological processes; development of standards; collection of innovation proposals). With this in mind, KM covers all levels of management, R&D, production and marketing, but may imply the creation of special units. Given the relationship with different management directions, it should be noted that KM eliminates problems and obstacles to productivity growth in various areas associated with the use of knowledge, resources, competencies, and sometimes immaturity of the company.

Figure 1 presents the main goals, principles and objectives (directions) of KM.

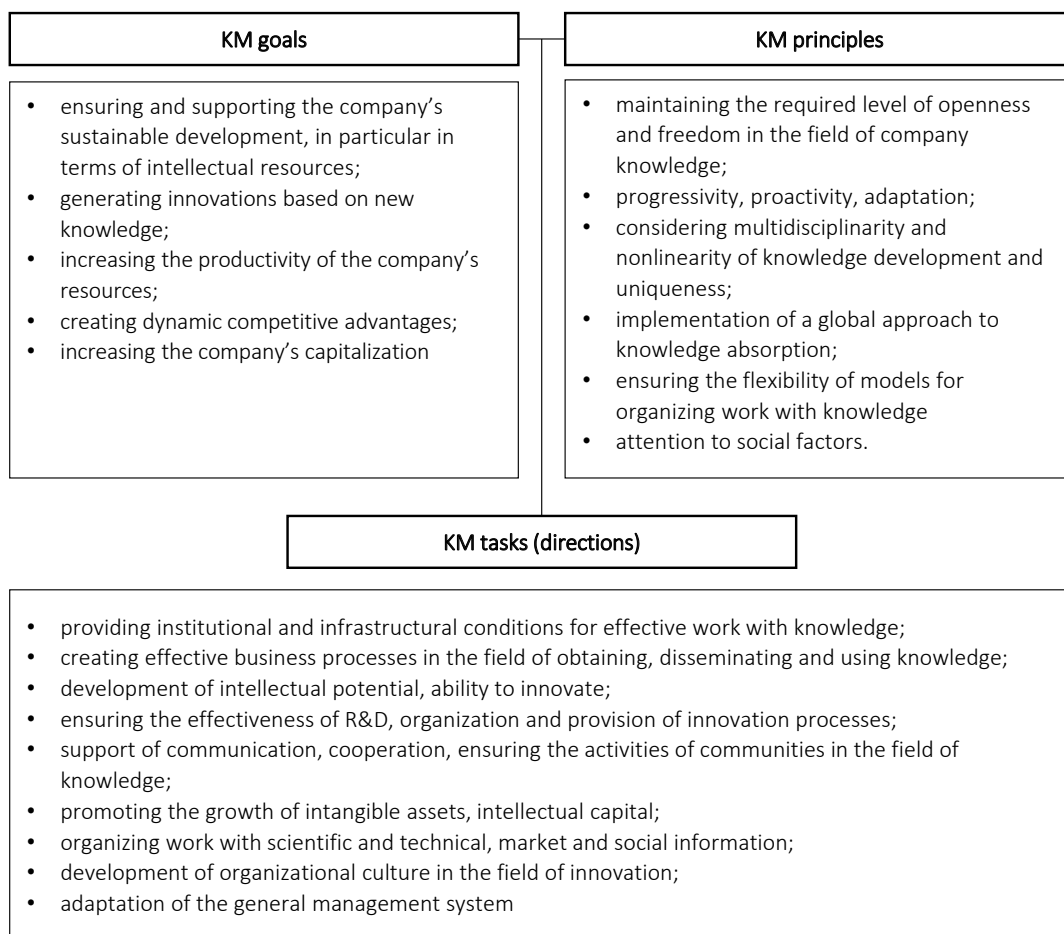


Figure 1. Goals, principles and tasks of KM

KM envisages a special strategy that is related to and affects the innovation, technology, personnel, and marketing policies of the company. Considering KM as a systematic activity, it is necessary to clearly structure its components:

- basic approaches: planned, social, competency, market, leadership, partnership, global, integrated;
- key processes: planning; organization of processes of obtaining, accumulating, disseminating and using knowledge; assessing knowledge, assets, efficiency; monitoring markets and the knowledge sector;
- management elements: plans, procedures, methodologies, instructions, standards, methods, organizational models, incentive systems, information systems and tools, etc.

The range method is wide enough and depends on the type of company, industry and type of knowledge and other factors. Among the individual methods, the following can be distinguished: smart cards, knowledge maps, etc. KM techniques refer to personnel management measures, innovation processes organization models, and project and information management methods. Separate categories are methods of knowledge assessment, data mining, methods of analysis and decision making.

Based on the tasks and components, KM is almost always social in nature, considers behavioral and personal aspects. It is directly involved in the creation of the company's internal environment, the formation of corporate culture and is aimed at stimulating productive intellectual activity. The social aspect is crucial for establishing the processes of communication, cooperation, learning, motivational influence and stimulating leadership. A special issue is the explication of skills, overcoming cognitive gaps, and maintaining mentoring relationships. The social dimension of KM also includes standardizing business practices, increasing the level of self-organization, initiative and responsibility, and developing trust. The social aspect determines the principles of using KM.

It is proposed to consider the internal and external dimensions of KM in their close interaction. In

the external environment, innovative companies actively cooperate with universities, research institutes, professional communities, and scientists. This is covered by KM and provides support for various ways of acquiring knowledge, for example: attracting specialists from outside, involving the company in research networks, acquiring technological developments, etc., which determines the ways of using knowledge in further activities. When it comes to the external dimension, it is necessary to focus on the widespread global monitoring of knowledge and innovation, focus on the global competitive environment and challenges, which also determines the content of KM.

The cornerstone of KM is the assessment of its effectiveness, which also has internal and external aspects. The internal aspect includes the analysis of efficiency of the company and its projects (especially innovative ones), the profitability of using resources, the productivity of departments and categories of specialists, and the increase in assets. This assessment is at the intersection of KM and other types of management. External efficiency is divided into three main areas:

- general economic performance of the company;
- the efficiency of the processes of obtaining knowledge from the external environment, and their use; and
- promoting innovation in the markets, changing competitive advantages.

When assessing the effectiveness of KM, it is crucial to assess the value of knowledge necessary for their sale and investment and evaluate the value of intangible assets. The known methods of such an assessment (profitable, costly, market, comparative) do not always give an idea of the value of knowledge, including in the absence of exact parameters of income, expenses, information about analogues, etc. Therefore, the company's advantage is its own methods of assessing knowledge, given their uniqueness, completeness, use, specificity of innovation, and technological change.

KMS is a multilevel set of elements that provide management of the processes of obtaining, dis-

seminating and using knowledge. It is designed to implement the goals, objectives and principles of KM and harmoniously combine various material, human, information resources to achieve its effectiveness. KMS subsystems are:

- 1) methodological (development of methods, techniques and procedures);
- 2) planned (development of strategies and plans);
- 3) administrative (creating special units and mechanisms, ensuring managerial influence);
- 4) information (creation of infrastructure, provision of information flows);
- 5) intellectual resource (work with scientific, technical and market-analytical information, development of intellectual resources);
- 6) functional subsystems:
 - a) obtaining knowledge (ensuring the receipt and/or generation, accumulation of knowledge);
 - b) dissemination and development of knowledge (diffusion, access control, staff adaptation, business process adjustment);
 - c) use of knowledge (ensuring the development and implementation of innovations).

KMS reproduces business processes of knowledge management in all divisions and projects of the company. For this, the general management structure and all types of the company's activities are being transformed. In terms of working with knowledge and KM, IT comes to the fore: special software, information portals and platforms (based on intranets and the Internet), information tools or solutions.

Information tools in KM. Given a comprehensive understanding of KM, including the dissemination of information, expertise, staff training, R&D and innovation management, a broader role for IT needs to be realized. Experience shows that IT can be useful for working with different types of knowledge (scientific, expert, analytical,

organizational, etc.) and the processes of obtaining, disseminating and using knowledge, which is their key value. Through the use of IT, transaction (interaction) and information costs are reduced, communication, knowledge processing, and big data processing are accelerated. IT simultaneously individualizes the work of employees and ensures their interaction, creating a new environment for cooperation. Thanks to IT, KM is more inclusive of both individual and collective activities.

Modern software covers a wide range of areas of knowledge: development of targeted communications, personnel training, data mining, work with scientific and technical information, networking, etc. Many types of information systems and software are associated with KM: corporate portals, intranets, search engines, communication systems, collaboration, project management, cloud computing solutions, online learning environments, knowledge description programs, expert systems, data warehouses, data analysis and visualization solutions, electronic directories, libraries, etc. CADD computer-aided design systems, ARIS business process design solutions, etc. should be considered separately. Integrated platforms are created to build knowledge bases (for example, Microsoft SharePoint or Atlassian Confluence). These systems and software perform many functions (categorization of information; managing content, data, tasks, and documents; feedback; organizational maps; decision making; data analysis, etc.), which greatly helps in working with knowledge.

However, due to the need to intensify innovation and the complexity of working with knowledge, it is necessary to expand the capabilities of intellectual activity of employees and innovation process management, which requires new information tools. It is proposed to focus on the following tasks: coordination of R&D units; organization and management of innovation processes; promoting knowledge dissemination within the company; organization of multilateral expertise; formalization of new knowledge, their accumulation and structuring; ensuring teamwork with the total amount of knowledge. In this regard, new information portals and tools are proposed that create a new quality of KM (Table 1).

Table 1. Information portals and tools in the company’s KMS

Tools	Description
R&D Management Portal (RDMP)	Supporting the R&D-based knowledge chain, covering individual projects. The portal should provide: planning of R&D directions and types, experimental work with linking tasks and generalization of results; providing specific communication and knowledge exchange. A distinctive feature of the portal is communication with all stages of the innovation process, step-by-step verification of R&D results, in particular marketing. R&D management should include a resource and risk management subsystem. RDMP should be included in corporate knowledge transfer mechanisms between departments and professionals. The structure and functionality of RDMP depends on the specifics of R&D and the company’s scope. RDMP is created as an intranet.
Innovation Management Platform (IMP)	Supporting innovative processes in the company, covering all their stages and activities. It functions as a single space covering all projects (teams) and divisions of the company. IMP creates the basis for networks of organized interaction, access to databases, various software, expert systems, etc., performs the functions of management and influence. The approaches and methods of KM depend on the type of innovation being developed and models for organizing innovation processes. Based on IMP, a virtual environment for innovation development will be formed, uniting different participants within innovation projects and units (taking into account the models of their organization by stages of processes, products, types of work), providing monitoring. Training and mentoring programs can be implemented under the IMP. IMP is created as an intranet, in some cases (for example, in open innovations) it connects to the Internet.
Knowledge Formalization Tool (KFT)	Support for activities to identify, register (provide a formalized form), systematize and store knowledge in order to develop knowledge resources and increase the efficiency of their use. For KFT, the main thing is to provide deep processing of information, full understanding, objective assessment of value and correct direction of knowledge. KFT should be used to summarize the results of R&D and brainstorming and other similar activities, processing scientific and technical information, external monitoring of knowledge, recording perceptions of objects, experiences and practices. Knowledge formalization can be carried out using a standardized editor; directories with automatic updating of information; tools for creating didactic materials; automated text processing systems; collection of facts; visualization models; systems of thesauri, classifiers, knowledge maps, etc. In some cases, it is advisable to use special tools for symbolic, logical and mathematical representation of knowledge. KFT as a separate software product (solution) can be created on the basis of various methodologies (in particular, Zettelkästen) and can be integrated into more complex systems.
Corporate Knowledge Base (CKB)	Support of activities and processes of accumulation, dissemination, synthesis of new knowledge, in particular in R&D, ensuring work with various types of knowledge, including poorly structured information. Knowledge bases are understood not only as part of expert systems or add-ons to databases, but as a target library (repository, directory) of a higher level with high-quality categorization and organization of knowledge, a wide range of functions for training, coordination, exchange, control, and audit. The need for CKB is due to the cumulative nature and complexity of knowledge organization. In addition to systematizing data and knowledge, CKB should provide the ability to analyze, disseminate (access control), search for data and knowledge, create collections or “mixes” to solve specific problems based on appropriate automated operations and mining components. Databases can be close to the specifics of scientific knowledge, which makes them the basis for working with scientific and technical information. As a tool to support intellectual activity, CKB becomes one of the main elements of RDMP and IMP, and is associated with KFT. Thus, CKB, by accumulating individual and collective knowledge, can provide “organization memory” for unique knowledge. Replenishment of CKB requires the development of an appropriate mechanism, and the resources accumulated in it require a special approach to assessment. CKB should become a tool that leads to R&D, an organic part of innovation and educational processes, competency networks, expert networks. CKB is created as a set of special software.

Portals and information tools create a new technological basis for working with knowledge, relevant business processes, and consolidate CMS. Their implementation should be complemented by new competencies, methods of work, changes in the organizational structure and culture, which requires the adaptation of personnel. In terms of expanding the functionality of working with knowledge, it is advisable to create the automated workplace of new generation.

4. DISCUSSION

Attention should be paid to the following key problems associated with the use of IT and the proposed portals and information tools in KM: inability to cov-

er all the variety of required knowledge; fragmentary presentation of knowledge for different categories of specialists; possibility of excessive specialization of work and access to knowledge, which leads to loss of vision; complexity of the effective division of labor in innovation processes and R&D; reducing the quality of information by speeding the process of obtaining it; narrowing freedom of action and creativity as a result of routine and control; deterioration of professional competencies in the field of knowledge due to excessive communication, irrational cooperation and compilation; the risk of errors due to reduced self-control and deterioration of competencies; difficulties in transforming information systems when conditions and purposes change. Table 2 illustrates the main problems of implementation, operation and improvement using CKB.

Table 2. The main problems of implementation, operation and improvement of the knowledge base

Implementation problems	Operational problems	Improvement problems
<ul style="list-style-type: none"> • design errors; • insufficient training; • staff resistance; • the difficulty of rooting in a culture 	<ul style="list-style-type: none"> • functional deficiencies; • gaps in the understanding of knowledge; • non-compliance with needs; • low quality of incoming information 	<ul style="list-style-type: none"> • continuity of knowledge progress, “mixing”; • low infrastructure flexibility; • changing the needs of employees; • uncertainty of tasks

These problems should be addressed within the framework of KM. The use of IT should be accompanied by constant monitoring of efficiency, in particular in the economic (assessing the value of knowledge, resource efficiency, innovation effectiveness, cost savings in various types of work with knowledge, costs of information, software and services), social (level of training and professional competencies, quality of work), and management (quality of management processes) aspects. Among the main areas of increasing the efficiency of the proposed portals and tools are:

standardization, assessment of quality and results of use; increasing the level of organizational culture; involvement of employees in their development. The proposed portals and tools in the form of software and intellectual capital are elements of a company’s intangible assets that can significantly affect the company’s capitalization. It should be borne in mind that such intangible assets may include external sources (for example, databases of scientific and technical information) and relationships with partners (universities, scientists), as well as cover various media.

CONCLUSION

The development of a knowledge management system is an important prerequisite for the processes of obtaining, disseminating and using the company’s knowledge. Given the goals, principles and objectives of KM, its approaches, key processes and methods, of course, for such management it is necessary to use the opportunities created by IT. Therefore, given the need to intensify innovation and the complexity of working with knowledge, it is proposed to introduce: a portal for R&D management, innovation management platforms, knowledge formalization tools, and a corporate knowledge base that reproduce new organizational models and create opportunities for effective work with knowledge. It is necessary to consider the problems of using IT in knowledge management. Further research is expected to provide guidelines on the valuation of IT-related intangible assets in the area of knowledge management.

AUTHOR CONTRIBUTIONS

- Conceptualization: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev.
- Formal analysis: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev, Natalia Nebaba.
- Investigation: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev, Natalia Nebaba.
- Methodology: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev.
- Project administration: Maxim Polyakov, Maxim Korneyev.
- Supervision: Maxim Polyakov.
- Writing – original draft: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev, Natalia Nebaba.
- Writing – review & editing: Igor Khanin, Vladimir Bilozubenko, Natalia Nebaba.

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