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A knowledge management system in the strategic development of universities

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Abstract

The purpose of this study is a conceptual description of the implementation of knowledge management systems (KMS) as a mechanism for universities' strategic development. Knowledge management (KM) practice from around the world proved the positive influence of KMS on productivity of educational institutions. The theoretical provisions and concept for KMS are determined based on an analysis of international experience of KMS use in higher education (HE). Theoretical provisions consist of 1) the staff activities as an object of KM and knowledge because of these activities, 2) the specificity of HE restrains a transfer of the KM mechanism from business to HE,

and 3) the uniqueness of each university determines the structure and content of KMS for strategic development. The KM process in HE is reflected in the Socialization-Externalization-Combination-Internalization (SECI) model, where each stage contains a list of staff activities and a set of digital services. The novelty of the KM process model in HE is that knowledge flows in a wave, not a spiral. In this motion, knowledge passes from uncodified to partly codified and codified form. The study demonstrates that knowledge can go the from stage of partly codified to uncodified for revision, and knowledge flow can stop at any stage. The advantage of the concept we designed is the ability to control the flow of knowledge before it takes the codified form of a document. The digital environment for KM first allows management to control faculty activities at the initial stage of uncodified knowledge through measurement of activities, and then to estimate the knowledge flow itself. The gathered indicators help to make decisions to motivate or restrain faculty. The university management gets a complete picture of faculty activities with knowledge and the intensity of knowledge flow in training courses and educational programs.

Keywords: knowledge flow, knowledge governance, digital environment, knowledge model, metrics

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Introduction

The strategic management of a university has to respond in a timely manner to ongoing changes in society, ensuring its development and the fulfillment by the university of its mission [1]. The source of the current transformation is digitalization, which creates new capabilities for universities and new requirements for structure and content of education [2–4]. Research into a proper way to meet the challenges of digitalization is within the responsibility of the strategic management of a higher education (HE) institution [5]. The purpose of the study is to present a conceptual model of knowledge management (KM) as a mechanism of university development in the context of the digitalization of society.

Business practice gives examples of implementation of KM as a tool for development of large companies. Relying on KM, companies create innovations, develop their personnel, and extend their activities [6, 7]. Corporate management has transmitted modern features to the theory and practice of KM. However, universities were the first to create knowledge management systems (KMS) based on scientific and learning activities. From the beginning, universities provided facilities for working with knowledge for society at large. Traditional methods and technologies in HE should be extended with innovative mechanisms in order to leverage the potential of digitalization for HE evolution and to respond to digital challenges properly.

Digital transformation, compared with the previous stage of technological transformation, is characterized by an increase in the complexity of knowledge [4]; acceleration of scientific and technological progress [8]; expansion of areas of interdisciplinary knowledge; an increase in the intensity of the use of intellectual assets [9]; the emergence of new forms and methods of professional employment of people [10]. These and

other characteristics of digitalization give rise to challenges to HE.

Overcoming the challenges depends on how the university organizes in a digital environment working with knowledge, including creation, acquisition, accumulation and use of knowledge, which is a main asset of HE. Meanwhile digitalization opens up new sources, technologies, and methods for KMS, which allow faculty to redistribute routine operations to IT and creative cognitive tasks to humans [11]. The high importance of KMS in HE is due to the great influence of HE on society and its transformation into a knowledge society [12].

1. Statement of research tasks

ISO Knowledge management systems – Requirements to establish a broad framework for KM definition and a variety of different tools and methods for KM [13], because the structure and content of knowledge are very specific for each industry or even activity. There is a generalized definition relying on sources [13–15]: KMS is an organizational and IT environment in which a set of available methods and tools are used by people to create, accumulate, store, search, enrich, exchange and apply knowledge.

The KM mechanism should be adapted to the specificity of HE in the context of digitalization in order to ensure achievement of strategic goals of university development. For conceptual design of KMS for HE, it is necessary to solve the following tasks:

- development of theoretical provisions of KMS in higher education,
- design of a conceptual model of KMS to support the strategic management of the university.

There are many different dimensions of activity and processes in any university. For study, the business process with involvement of most of faculty staff is under the spotlight of consideration. This business process is development of training courses and educational materials. Deja [14] and Yeh [15] highlighted this specific activity as an academic KM.

2. Literature review

Some KM methods penetrate into the operational level of universities' everyday staff activities. Tools embedded in KMS such as network drives, web-services and messengers are actively used by teachers in the educational process for collaboration and sharing [16]. Occasionally implementation of a method or tool from a KM toolbox is not tagged as KMS by researchers. Publications that consider KMS as a field of science can be classified according to KM objectives. KMS can be focused on development of innovation [17], maintaining partnerships with businesses in industries [18], promotion technological transformation in HE [19, 20], facilitating e-learning [21] and teaching the theory and practice of KM [22, 23].This list of KM objectives is not complete due to the huge variety of tasks and dimensions in HE. Meanwhile Quarchioni et al. [24] summarized KM practices in HE as six conceptual approaches to the KM objective: 1) control of intellectual assets, 2) transfer of knowledge and best practices, 3) improvement of KM technologies, 4) KM training, 5) creation and sharing of academic knowledge and 6) implementation of KM.

KM in HE as a scientific field is multidisciplinary, so papers on the topic "knowledge management in higher education" cover 123 research areas in the Web of Science. There are 3102 publications retrieved in the Web of Science for 2000–2020 period: 29% of the papers are in the research area of education, 25.1% – business economics, 9.7% – engineering, 8% –computer science, 7% – information science and library science. Most of the research findings on KM in HE are focused on the practice of solving operational tasks in HE. Only 1% of the papers raise issues of KMS in strategic management in HE.

The practice of KMS in strategic management has already been studied in several universities which are

included in the World University Rankings[1]. The experience of King Abdulaziz University in Saudi Arabia [25] demonstrates an organizational culture as a main driver of KM. Italian University of Bari [26] and Ca' Foscari University of Venice [27] use facilities of KMS as an environment for interactions between academic and business communities, also as a mechanism for attracting enrollees. In China's Wuhan University of Technology [28] and in India's University of Delhi [29] KMS is implemented to ensure demand for their graduates and future employment. Another Chinese university, Northwestern Polytechnical University [30], uses KMS to enhance research activities among faculty staff and students. A case study of Moscow State University of Economics, Statistics, and Informatics (Russia) presents KMS as a means for innovative transformation of education into e-learning [31]. Consideration of the above sources shows that the effectiveness of KMS is measured through indicators of university performance. There is a huge experience of applying of the performance indicators for strategic management in HE on large simulation systems, decision support systems and business intelligence [32]. Digital transformation projects, regardless of the field of activity, are always aimed at the strategic development of an organization [33, 34].

Meanwhile, a conclusion about the positive impact of KMS on university performance can hardly be drawn without exclusions due to the so-called survivor bias. In the sources under consideration, the assessment of KMS influence on university performance is based on a survey among students [29, 35, 36] and lecturers [25, 37] to show their satisfaction with KMS and the relevance of KMS to their activities. It is necessary to take into account the limitation of the method of surveys and expertise in evaluating performance when interpreting the results. The conclusions drawn from our review of literature cannot be extrapolated to the entire HE due to differences in the understanding of KMS and its tools on a case-by-case basis.

Several studies have been carried out on a national scale covering the practice of KMS at a few universities: in the United Kingdom [36, 38], Australia [39], Spain [40, 41], Poland [14] and Malaysia [31, 42]. In studies at the national level, the tasks of the KMS are revealed in the context of state regulation and regional specifics. National HE systems differ significantly from each other, but they are united by the dominant influence of public authorities on the operational and strategic activities of universities. The introduction of KMS in Italian [27] and Australian [39] universities may be hindered by regulations. In Poland, the KMS is supported and implemented at the national level as a mechanism to ensure the transparency and manageability of intellectual assets at each university and throughout the country [14].

It is quite difficult to single out a universal structure from the sources of the KMS which could fit universities of at least one type. Moreover, in other industries there is no shared understanding about KMS structure and content. Common to HE and other industries is the awareness that KMS supports and ensures the achievement of strategic goals. A review of the literature shows a gap in the disclosure of the conceptual scheme of the KMS as a mechanism for strategic management of the university in the context of the digitalization of society. The academic community will have to conduct full-scale studies of KMS in the strategic management of the university.

3. Methodology of the study

The empirical data for studying the content of KMS in strategic management in HE were extracted from sources describing KMS practice of universities located in Australia [39], the United Kingdom [36, 38], India [29], Italy [26, 27], Spain [40, 41], China [28, 30], Malaysia [31, 42], Saudi Arabia [25], Poland [14] and Russia [31]. Methods of analysis, comparison and generalization are applied to develop the theoretical provisions of KMS.

[1] World University Rankings https://www.timeshighereducation.com/world-university-rankings

Methods of categorization [43] and semantic modeling [44] are used to design a conceptual model of KMS in strategic management in HE.

Because of the huge number of university activities, the study is limited to considering the processes of developing educational programs and its educational and methodological content, i.e., academic knowledge. An attempt to cover all university fields at once could lead to blurry, non-specific results.

4. Research results and discussion

4.1. Theoretical provisions of KM in HE

4.1.1. KM Object

Universities were the first organizations to hold KM systematically. Their managerial activity focused on knowledge accumulation, storage and dissemination. The relevance of knowledge control appeared in the processes where the value of knowledge is prioritized as assets. The first business cases of KM considered the problem of knowledge retention that arises when an employee generation changes [7]. A well-known and widespread solution to this problem is documenting and storing information about knowledge in an information system, library or knowledge base. Knowledge has been defined for centuries as subjective [45], which does not exist outside the context of human activity. Thus, information systems store information about knowledge and not the knowledge itself. Recent studies support the concept of knowledge as a subjective category [46] and expand the list of knowledge subjects to include an organization and a local community [6, 11, 47]. Therefore, an organization can learn, create, store and use knowledge. Organizational knowledge as a management resource is characterized as intellectual capital and connects human, social and operational assets [48].

The subject property of knowledge determines the priority of the qualitative measurement of its value over quantitative characteristics [14]. The academic community discusses the issue of qualitative measurement of scientific results because the quantitative measurement through the evaluation of bibliometric indicators does not reflect the level and significance of scientific results [49]. The quantitative measurement should be given by an expert in a proper scientific area [50]. Expertise of study is a time-consuming and expansive method, so it can be applied to cases where the main function of KMS is distinguishing the most important knowledge. If the main function is creation, sharing, dissemination and modification of knowledge, the expertise will slow down KM processes. When the scientific and technological progress is accelerating, such a slowdown of KM limits the flexibility and intensity of work with knowledge.

The processes of external and/or internal peer review are used to approve the syllabus of training courses in almost all Russian universities. The process of assessing the quality of knowledge is laborious and cannot cover the entire volume of knowledge circulating at the university.

Early MK theories relied on various surrogates for knowledge to separate knowledge from humans and extract the most valuable information from the available content. Founders of KM theory Nonaka and Takeuchi [6] chose the use of knowledge by people as a sign of knowledge that is of value to the organization. Kurlov and Petrov [51] for the purposes of innovation management introduce a concept of instrumental knowledge on the basis of which an activity is transformed. The ISO [13] deals with the value of knowledge, not knowledge itself. In order to consider KMS as a mechanism for strategic management, it is necessary to put aside the discussion about the structure and content of knowledge.

The value of knowledge is defined by staff activities with knowledge in the performance of their labor functions. Thus, staff activities regarding to knowledge should be considered as an object in KMS. The first theoretical provision is that the object of KMS is the activity of users in the knowledge environment.

ISO [13] defines an environment that provides favorable conditions for people to work with knowledge as a common means of KM. In a broad sense, the environment contains the internal capabilities of the organization and a part of the external sources of knowledge and experts. In a narrow sense, the environment is supported by the KMS, which is a set of organizational and information solutions for performing the functions of the KM. Through KMS employees get access to knowledge, can interact with each other, and use different methods and tools to work with knowledge.

Staff activities drive the knowledge flow in educational and other areas of universities. A study of communication between lecturers shows their high appreciation of the opportunity to interact with each other [52]. A series of conversations conducted with Nobel laureates in economics emphasizes the great role of the communication environment in their scientific progress. World science leaders highlight the importance of informal discussion of hypotheses and theories with colleagues [53]. The stage of informal discussions is included in the cycle of scientific and technical information, including non-published materials; from this stage the life cycle of knowledge begins in the knowledge management system of the state corporation Rosatom [7].

4.1.2. Specificity of KM in HE

The spread of KM technologies and methods among businesses is uneven. Almost every industry has its own KM methodology. The need to adapt and develop a special approach to KMS for a given industry is due to the specific properties of knowledge for each industry and even organization [13, 54]. The dependence of knowledge on subjective interpretation in the context of an industry makes it difficult to directly transfer best KM practices across industries and organizations.

KMS as a mechanism for strategic development came from the business community to HE [55]. In business, various ways of implementing KMS are used which differ depending on the goals of strategic development and the industry or market specificity where the organization operates. Rosatom developed the KMS based on the scientific and technical information system to control codified (documented) intellectual assets [7]. The Japanese companies Honda Motors and Eisai relied on the knowledge environment in which employees have a deal mainly with uncodified (undocumented) knowledge [56].

The specifics of HE institutions influence a methodology of KMS for universities. The main feature lies in setting a goal of strategic development. Kuzminov and Yudkevich [1] point out that goals of strategic development for Russian universities are set by public authorities. There is also a dependence of the national HE system on budget funding, which limits any initiative of universities in choosing their own way of development. A large role of public authorities in the KM practice in HE stands out in Australia, Italy and Poland.

The KM environment is often considered from the perspective of its three enlarged groups of elements: people, processes, technologies [57, 58]. Through human activities, knowledge acquires its value and meaning. Often a department responsible for personnel development also is responsible for KMS. The processes performed in an organization determine the possibility and space to include KM activities into the business. These processes impose requirements on the structure and content of the KMS. Organizational development policy and regulations should rely on KMS and describe the KMS contribution to performance of the organization and productivity of employees. Current digital technologies provide KMS with ingenious tools for creating and sharing knowledge. The emphasis on one of three enlarged groups of KMS elements puts responsibility for KMS on the HR, administration, or IT department of an institution. *Table 1* summarizes the features of KMS at universities by people, processes and technologies.

Table 1.

Features of KMS in HE universities

Group of KMS elements	HE feature
People	Confirmed high intellectual potential of employees (scientists and lecturers) [3, 40]
	The ability to use intellectual potential from the business environment through graduates [59]
	Employees' acceptance of the value of the free exchange of knowledge for the development of education and science [42, 60]
	Academic competition among faculty staff [36]
Processes	Conducting research and educational programs in a large number of fields [61]
	Diverse approaches to forming and supporting creative teams and projects
	Priority for fulfilling the public mission of science and education [35]
	Integration and intensive interaction with external communities [3, 40]
	Strict regulation and control by public authorities of HE [62]
Technologies	External content sources: digital libraries, databases
	Scattered internal sources of content: teaching materials, scientific reports, regulations, etc.
	Strict information security requirements apply to work with personal data, but not to content that is created, used and distributed in education and research
	The concept of "BYOD" according to which the lecturers and students themselves choose the computers, software and web services that are suitable for them in terms of performance and cost [63]

The second theoretical provision is that design, structure and contents of KMS for universities should take into account the features of HE in order to fully realize the high intellectual potential of employees and cover many scientific areas and training courses with the help of the heterogeneity of IT facilities for education and science.

An analysis of the KMS practice in universities shows that each group of elements contributes to success and strategic development. Elements of KMS

provide cultural [25], organizational [39] and technological [41] conditions for the success of KMS in HE.

4.1.3. Adaptation of the KM mechanism to strategic goals of university development

KMS as a mechanism for strategic development is based on the mission and values of the university [56]. KM cases in universities differ significantly from each other, but their common features are revealed when they are grouped by mission type. The practices of KM implementation in universities follow a common mission type and also have common features. There are three types of mission in HE: educational, scientific and the so-called third mission. The third mission appeared because of changes in society under the influence of scientific and technological progress, economic globalization, political and economic crises [64]. The third mission of the university directly influences the socio-economic development of a city or local area by facilitating interaction between communities of entrepreneurs and citizens, the dissemination of best practices and new business models, etc. [65]. Meanwhile universities staying on their educational and scientific mission indirectly influence societal development through their graduates and scientific results. Universities have been guided by an educational and scientific mission for centuries. Lomonosov Moscow State University nowadays follows the mission formulated in the 18th century[2].

The productivity of KMS is measured by the performance indicators of a university. Based on analysis of the KM practice in different universities, the characteristics of KMS are extracted in accordance with the type of mission in terms of geographic scape and KM means (*Table 2*).

The university's educational mission focuses on the value of professional evolution and demand for their graduates. Employment of graduates is regarded as one of the main key performance indicators of the university. Therefore, KMS aims to ensure that graduates of educational programs are in demand in the labor market. Universities with an educational mission conduct their activities in selected regions to build relationships with employers and interact with the labor market.

The scientific mission of the university sets a task for strategic management to advance in world rankings, promote papers in top scientific resources and obtain world-class scientific results. These tasks determine the global scope of KMS [67]. The activities of faculty staff in dealing with knowledge may be located outside a campus. Case studies of research universities raise the issue of negative impact of some tools or practices of KMS on performance indicators. An analysis of the implementation of KMS by 70 Spanish universities found a relationship between the spread of IT for collaboration and a decrease in the number of publications in top-cited journals [41].

Universities of the third mission focus on the social, cultural, and technological development of a particular region, such as a city [68]. The third mission is most often characteristic of entrepreneurial universities [26], which act as a connector between businesses, citizens and public authorities [65]. In smart cities projects, universities perform functions of generating, collecting and selecting knowledge to fill a lack of scientific and educational expertise in business and society. Rapid changes in technology, the economy and society require HE institutions to diversify sources of knowledge and ensure their transfer to society. Thus, universities link parts of a societal ecosystem: production, education, public administration and research. The considered cases

[2] Mission of Lomonosov Moscow State University: "the education of peoples for the benefit of our common humanity, ... for the well-being of the entire fatherland". Source: Program for the Development of Lomonosov Moscow State University until 2020. Government of Russian Federation. Order of September 27, 2010. No. 1617-r. http://pravo.gov.ru/proxy/ips/?doc_itself=&nd=102141648&page=1&rdk=5&link_id=6#I0 (in Russian).

Table 2.

Characteristics of KMS for mission in HE

	Educational mission [25, 28, 29]	**Scientific mission** [30, 40, 63]	**Third mission** [26, 27]
Key performance indicators	employment, competencies, education, employer, student satisfaction, rating	publications, rating, citations, patents on scientific results, innovations	innovations, competitive advantage, value, strategy, improvement of society
Geographic scope of activity	In selected regions or countries	Global	Regional
The most typical knowledge management tools	Corporate portals, collaboration tools based on cloud computing	Communities of practice [66], knowledge libraries, variety of information sources, collaboration tools	LivingLabs [65], communities of practice

of the use of KMS in universities of the third mission show a local or clearly defined regional scale of their activities.

The third theoretical provision of KMS in HE is to ensure that the university fulfills its mission. At the same time, the productivity of KMS is measured by the key performance indicators of the university, and not by the performance of individual functions of KM.

Following key performance indicators in the strategic management of the university is the basis in BPM (business performance management) systems, which are already used in HE [32]. Thus, KMS can be embedded into an existing IT landscape of strategic management using the available IT infrastructure for data storage and analytical processing.

4.2. Conceptual model of KM

4.2.1. Conceptual scheme of knowledge flow in HE

The activities of faculty staff drive knowledge flow in the university, which goes through stages from the birth of an idea of knowledge (creation of a training course) to its use and distribution in codified form as educational and methodological materials. In HE, knowledge is often understood as scientific and technical information, and a process of creating knowledge goes through a cycle of unpublished knowledge, primary sources of knowledge publication and secondary sources of knowledge publication [7, p. 75]. In business practice, the SECI model by Nonaka et al. [56] is widespread. This model of crea-

tion and use of knowledge in organizations consists of the stages: Socialization, Externalization, Combination, Internalization (SECI). The authors of the SECI model distinguish the stages depending on the degree of knowledge codification and the number of participants involved. Based on the SECI model, *Fig. 1* shows the stages in the development of teaching and learning materials. *Figure 1* demonstrates a sequence of stages in a clockwise direction. The inner circle contains a list of staff activities, and the outer circle contains the means of digital environment for performance of these activities. For three stages (E, C, I), types of codified knowledge are given as an example, and the figure does not contain a complete list of possible documents.

Stage S is the initiation or relaunch of a knowledge project. The stage consists of interpersonal interactions of a few lecturers. The results of this stage can be recorded in the form of drafts and a set of ideas, but they are not published as documents. Thus, knowledge is not registered and included in information systems or libraries, because it is uncodified. E-mail or social media can be used at this stage. Participants are a small group of authors.

Teece [69] points out that supporting staff activities with uncodified knowledge ensures intellectual assets as a stable source of competitive advantages for an organization. In Russian universities, this stage is practically not controlled by management since it takes place in the lecturers' environment and is not supported at the university level. Consequently, universities do not receive possible benefits for their development from the stage S of creation of educational materials.

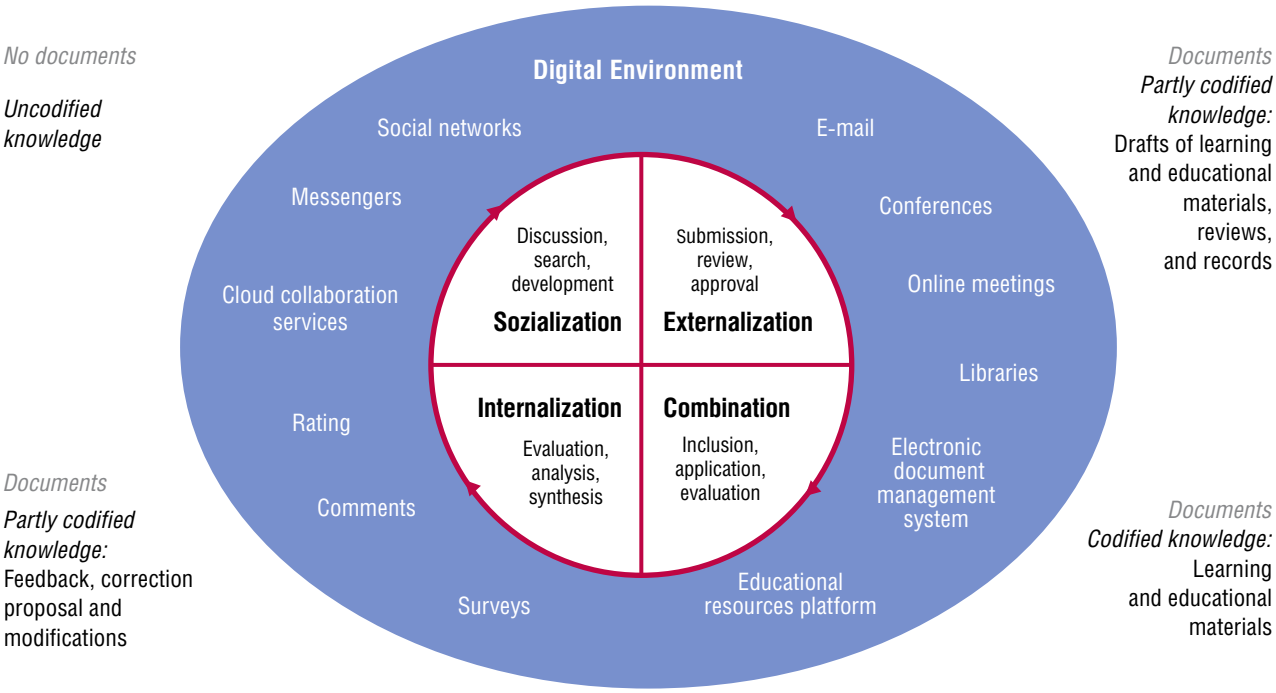

Fig. 1. Process of development of learning and teaching materials at SECI model.

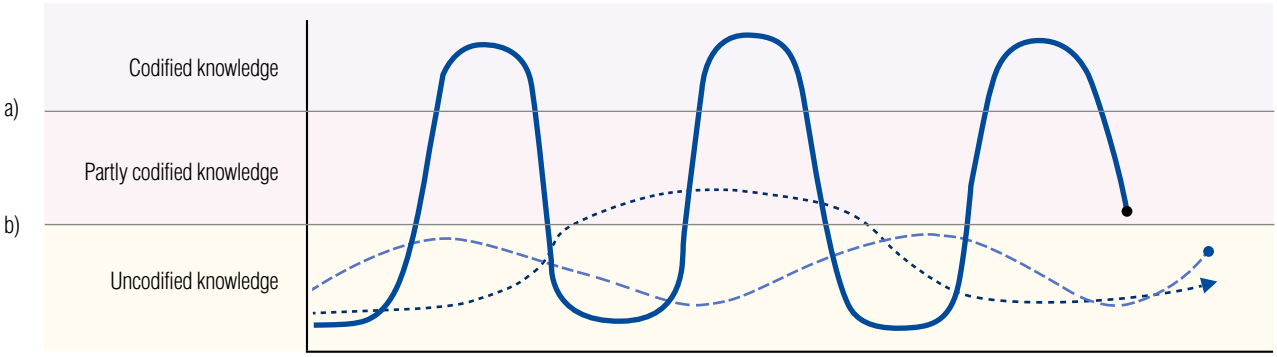

Fig. 2. Academic knowledge flow.

At **stage E**, knowledge is partly codified to involve more people in knowledge processing such as the review, discussion and approval of materials submitted by authors. The approval of educational materials could be done in different ways. At HSE University, an academic council of the educational program reviews and approves a syllabus of training courses. At the Plekhanov Russian University of Economics, this is done by a scientific methodological council of higher schools.

Educational, learning and teaching materials are codified at **stage C**, when materials are approved and accepted. At this stage educational materials become available in libraries and information systems. They are open for lecturers and students to use in training courses of the university.

The final **stage I** in the KM process includes an assessment, feedback, analysis and synthesis based on the experience of using knowledge. At stage I, we find the students' assessment of their learning experience during a training course and the lecturers' assessment of their teaching experience. The knowledge gained at stage I is codified as ratings, proposals, comments and recommendations on the results of the analysis and the synthesis of practice to use the materials.

The SECI model is often presented as a spiral on the timeline, where knowledge sequentially passes through the stages, and the cycle of working with knowledge is repeated on a new round. The development of training and methodological materials in general goes through all the stages of SECI, but trajectories can be different. The different trajectories arise because knowledge can move back and forth. For instance, after discussion on stage E a syllabus returns to the previous stage S for a revision. Thus, on the timeline, the knowledge flow looks like a wave. *Figure 2* is a schematic presentation of academic knowledge flow, where the *x*-axis is a time scale, and the *y*-axis is a categorical scale reflecting the levels of knowledge codification.

In *Fig. 2* the wave shown by the solid line crosses level *a* of codified knowledge three times. That means that the training materials went through three full cycles and were used in the training course. On the peak of the wave, the educational materials are being approved and accepted. Waves shown in dashed lines do not reach the stage C and cross level *a*; they do not enter a library or repository; and they are not introduced into training courses. Meanwhile the work on this material is ongoing. The full stop at the end of the wave means the end of work on materials. Some flows of knowledge are stopped after a week, while others can run on for years. Knowledge flows differ significantly in the duration and intensity of the waves, depending on a training course, scientific area, moti-

vation and competence of the author team. If in some scientific areas a life cycle of knowledge can be more than five years, then in others it will not exceed a year [70]. Knowledge flows in various areas of training and scientific areas can take various periods of time from several weeks to years.

The number of knowledge flows in a university can be indirectly measured through the number of educational programs and training courses. Knowledge flows can be grouped in an educational program or a scientific area based on departments.

The model of academic knowledge flow offered here does not change the usual course of its development but formalizes it for control and management. The traditional approach to KM through a codification and storage of knowledge in libraries allows universities to control knowledge that entered a library in codified forms as syllabus, curricula, textbooks, etc. The importance of libraries as knowledge repositories is not subject to revision, but they should be complemented by digital means that support knowledge operations and interaction between employees. The staff activities use partly codified knowledge and are partly controlled by the administration. All activities below level *b* are out of sight for the university administration. The flow of knowledge in the digital environment allows the administration to bring all its stages out of the blind zone and ensure control over them.

4.2.2. System of indicators for knowledge flow measurement

The main function of KMS is to support the knowledge flow which is provided through measurement and control. The control of knowledge flow requires a system of indicators to assess the state, intensity and volume of knowledge flows.

The digitalization of society enhances the transfer of many activities and processes to the digital environment. One of the advantages of the digital environment is the ability to automatically gather data on selected metrics. The modern knowledge environment is a digital environment. A significant part of activities with knowledge is carried out using digital services, such as e-mail, messengers, online conferences, collaboration through cloud services and network storage disks. Thus, the digital environment of KM meets the necessary condition for the automatic measurement of the staff activities driving the knowledge flow in motion.

The SECI model shows that knowledge codification is preceded by the stage of knowledge emergence, which assumes operations with implicit knowledge. It is impossible to measure uncodified or implicit knowledge, but it is known that it appears in staff interaction. This stage is usually not considered and controlled by the university administration. The existence of implicit knowledge in KMS can be compared to the phenomenon of a black box in cybernetics, in which input and output can be under control, but not inside of the black box [71]. Precisely at stage S (socialization) there is the occurrence of new knowledge or adaptation of already known knowledge to changes and new requirements.

The digital environment allows for capture of the state of each stage of the knowledge flow and control of its progress. The object of control in KMS is a staff activity; therefore, the system of indicators of the knowledge flow quantitatively measures the staff activities in the knowledge flow. In accordance with the SECI model for the stages of developing training materials, the indicators can be grouped as follows:

1) interaction and communication between employees characterize stage S, which does not contain codified knowledge;
2) contribution of employees to the knowledge library – stage C;
3) knowledge sharing at stages E and I, where knowledge is partially codified. In the knowledge flow scorecard, these two stages are combined because they both involve discussion and interaction involving a group of stakeholders (a supervisor of the educational program, students, lecturers, etc.).

The knowledge flow indicators are presented in *Table 3*, which contains a short description of source, data type and method for measurement.

A comparison of values of the indicators of knowledge flows for different training courses and educational programs is a function of KMS specific to HE. Similar values of staff activities at stage S for most of knowledge flows point to a homogeneity of the organizational culture at a university. A means for managerial impact on promotion of the organizational culture is justified by measuring the indicators of stage S. If the values of staff activities in one knowledge flow are lower than in other flows, then this indicates the disunity of the lecturer team in the area. In business, the phenomenon of sabotage is known [72]: this is when employees deliberately exclude themselves from the flow of knowledge.

At stage C, the contribution of a lecturer to the accumulation and keeping of knowledge is assessed. Meanwhile, the value of knowledge is not assessed. The indirect assessment of the value of knowledge through its relevance supposes a risk that some knowledge may be underestimated and lost. This risk was first described in the middle of 20th century, when it was discovered that society does not have enough capacity to store and process the entire information flow which is permanently growing and varying [73]. Despite the breakthrough development and spread of digital technologies, this risk remains relevant [74].

Knowledge sharing indicators characterize the stages of work with partially codified knowledge when other persons in addition to the authors join the knowledge flow to discuss and improve materials. Values of these indicators point to the intensity and volume of the flow of knowledge, and help determine the need for support for staff activities in the stages E and I.

The knowledge flows of a contemporary university are growing and changing all the time. The digital environment is suitable for measuring and considering the processes of working with knowledge. The stages of creation and use of academic knowledge become transparent for control and, therefore, manageable.

KMS should be considered as one of the application layer elements of the IT architecture of a university shown in *Fig. 3*. Using the service approach, KMS is integrated into the IT landscape of the university in such a way as to use the capabilities of the multidimensional warehouse for storing and processing the indicators of the knowledge flow, and BPM systems for measuring performance indicators and evaluating the performance of KMS.

On the one hand, KMS uses the possibilities of digitalization in terms of simulation modeling and predictive analytics of knowledge flows. On the other hand, KMS complements the strategic management systems of HE with data on the flows of knowledge, all of which have a decisive impact on the university performance.

Conclusion

In the context of high technological and economic dynamics, the university, along with business, needs a favorable environment for creating innovations that ensure its development. In business practice, an approach using methods and technologies of knowledge management has become widespread. These means, combined in KMS, can complement traditional higher education approaches based on scientific research and systematic university staff training.

The specificity of KMS in higher education lies in the fact that the object of control is the activities of faculty staff for the development, modification, discussion and use of educational materials. The flow of academic knowledge is set in motion by lecturers from the birth of an idea to its implementation in the educational process and subsequent refinement. KMS introduction in the university requires taking into account the specifics of higher education, such as a large number of training courses and scientific areas, the proven high intellectual potential of staff, and

Table 3.

Indicators of knowledge flow in KMS

Groupe of indicators	SECI stage	Indicator	Source	Type of data	Type of measurement
1. Interaction and communication between employees	S	1.1. Communication intensity, number and frequency of messages sent and received	Digital interaction services: e-mail, messengers, forums	Numerical	Frequency, quantity
	S	1.2. The content of the interaction, messages sent and received	Digital interaction services: e-mail, messengers, survey	Categorial	Content analysis
	S	1.3. Coverage of interactions, number of lecturers involved in interactions	Digital interaction services: e-mail, messengers, forums	Categorial	Frequency, quantity
2. Contribution of employees to the knowledge base	C	2.1. Download of materials	Knowledge library	Numerical	Frequency, quantity
	C	2.2. Content of uploaded content	Knowledge library	Categorial	Content analysis
3. Knowledge sharing	E, I	3.1. The intensity of reviewing, commenting, feedback on colleagues' materials	Reviewing and commenting services	Numerical and categorial	Number, volume of reviews (comments)
	I	3.2. Rating, feedback on practice of knowledge use	Digital interaction services: e-mail, messengers, survey	Numerical and categorial	Number of ratings
	E, I	3.3. Commenting	Digital interaction services: e-mail, messengers, survey	Numerical and categorial	Number, volume of comments
	E	3.4. Update intensity, number of versions and frequency of changes	Knowledge library	Numerical	Frequency, quantity

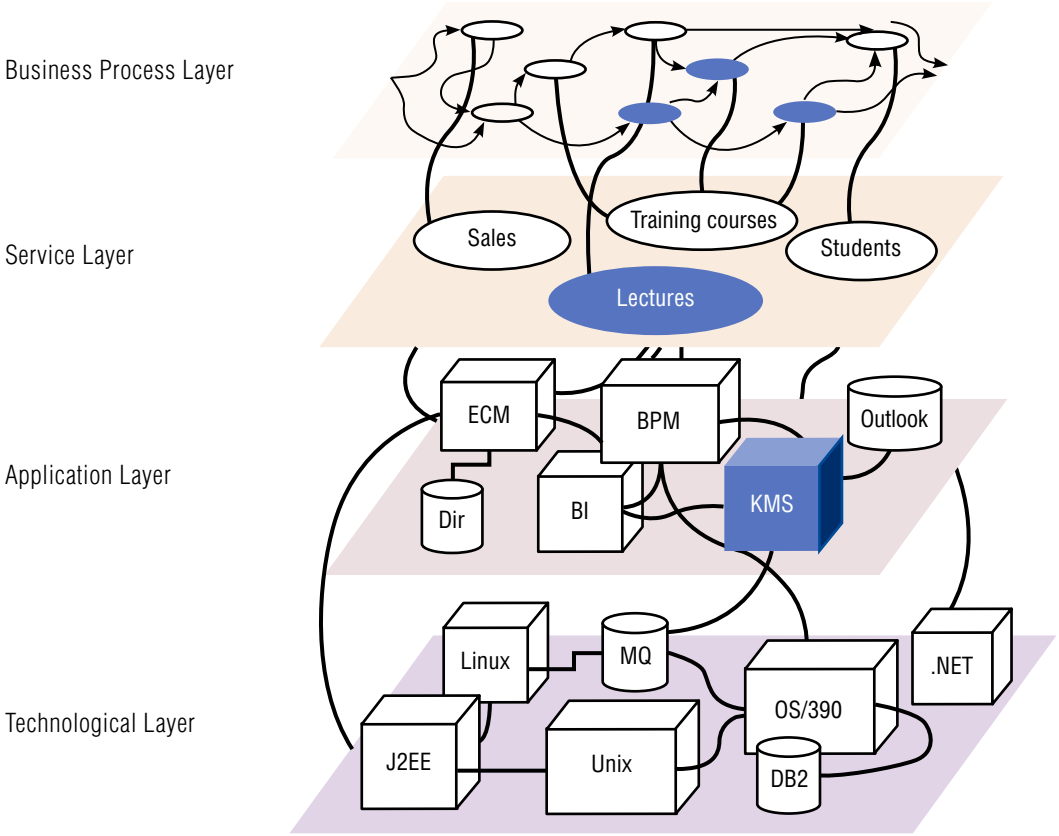

Fig. 3. KMS in IT architecture of university. Source: the figure is adapted from [34, p. 229].

the disparate IT infrastructure of the university with many involved technologies and knowledge sources. Also, the methods and technologies in KMS should be adapted to the individual needs and capabilities of each university which are determined by the mission, region, scale and other parameters. The specifics of each university make it difficult to develop a standard of KMS suitable for all institutions of higher education but do not prevent knowledge flow modeling.

The flow of academic knowledge at the university is presented based on the SECI model of the process of creating and using knowledge in organizations. Our modified SECI model, adapted to higher education, contains a list of activities and digital services that ensure the motion of the knowledge flows. The flow moves in waves through the stages of uncodified knowledge (S), partially codified (E, I) and fully codified knowledge (C). Currently almost all knowledge management functions are carried out using IT, which allows us to control the indicators of the intensity of the knowledge flows.

A knowledge flow in the digital environment become a transparent to measure its scope, intensity and volume. Timely and informed decision making relies on the measurement of knowledge flows. The proposed system of indicators measures the interaction and communication between faculty staff, their contribution to the creation of educational materials, their

participation in collaboration. Since many knowledge flows exist simultaneously at the university, by comparing the flows with each other it is possible to identify the most and least successful practices and have an appropriate impact on staff.

The modern methodology of the KMS makes it possible to form a set of events to involve almost all university staff in the development and dissemination of knowledge. A university that does not fully control the knowledge flows does not have a complete understanding of the innovative potential of its strategic development. Further research in the field of KM in higher education is aimed at developing the principles of KMS at universities, structuring the methods and technologies of KMS by levels of management and areas. The authors of this study are working on testing the theoretical and methodological provisions of KMS proposed in the article at a team level in Russian universities. ■

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