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# Information Model for Monitoring the Development of the University

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ABSTRACT Higher education institutions are becoming increasingly complex and self-developing systems. Monitoring the activities of such systems requires a special approach and includes three main elements, that is, external monitoring, independent evaluation and internal monitoring. In the framework of this article, the main task of monitoring is the analysis and disclosure of internal patterns, causes and trends of the development processes of a university. In these conditions, the need to move to a broader model for solving and reducing complexity based on information and knowledge is revealed. The model reduces the uncertainty of the environment and thus provides more effective decision-making. The monitoring model includes changes in the strategic planning process that are consistent with the characteristics of the new organizational model. Ontologies, as a theory of content, which allow formalizing processes and knowledge, are a key element in this context.

KEYWORDS Management; Indicators; Monitoring of university activities; Ontological model; Information system.

## I. INTRODUCTION

AN important component in evaluating the effectiveness of universities is the evaluation of their scientific and educational activities, which is monitoring.

Currently, there is no unified approach to monitoring issues, just as there is no unified specialized information system for operational analysis and management of performance indicators of universities. A review of approaches to monitoring the activities of universities has shown that they and their information systems are based on analyzing data that are performance indicators of effectiveness, comparing them with target values, and visualizing them [1-7].

If we assume that the performance of effectiveness is evaluated only by assessing the achievement or non-achievement of goals, then many of these systems achieve their desired goals. In matters of strategic planning and monitoring the effectiveness of the university activities, that is not enough; it is necessary to identify the reasons for failure to achieve results based on the final results and determine the ways of further development.

The special feature of the university as an object of strategic management is a high level of decentralization, the need to involve the maximum number of stakeholders in the strategy development process [8-11]. Another feature of building a strategic management system is the need to collect a large amount of poorly structured information necessary for analyzing the current situation. The university's strategy includes the necessary level of results in relation to inputs and processes. Nowadays, universities determine their strategy based on calculating their position in the market – the main source for comparative rating agencies, on internationalization carried out in university processes, and on calculating the impact of universities on the locality or region [12]. Ensuring the quality of education has become a necessary prerequisite for the accreditation process, as well as a position in the rating.

The purpose of this article is to design an information model for monitoring the development of a university based on an ontological approach to solving monitoring problems: to reveal the internal patterns of change in indicators, cause-and-effect relationships between them and possible trends in university development. The article considers the main tasks of university management, reveals the goals and objectives of internal monitoring, reviews existing methods and systems for monitoring university activities, and identifies the reasons for the impossibility of their mass implementation in universities. An information model for monitoring university development based on an ontological model with a detailed description of the results of the work in the usage scenario section is proposed.

## II. THE UNIVERSITY MANAGEMENT PROBLEMS

The University is a complex, multi-functional, multi-level system with a specific mission: to meet the intellectual, cultural, and social needs of the individual, society, and the state in the process of "producing" highly qualified professionals – people with intellectual and innovative potential [1]. Modern universities are considered as complex self-developing open systems that are characterized by high activity and advanced development, taking into account and ensuring a balance of interests of external and internal partners. Addressing issues of improving university management requires an integrated, systematic, and process approach.

The university management model is based on strategic management and focuses the university on continuous improvement of quality and meeting the needs of the labor market.

Today, the system of control and monitoring of higher education institutions includes three main elements:

– external monitoring and control of the university activities (international and state rating);

– independent assessment of the institution's activities (accreditation);

– internal university monitoring and management control system.

Of course, external monitoring and independent evaluation are important means of regulating the university activities and largely determine the content and direction of making a decision, but the internal monitoring system still plays a decisive role in the effective management of the university's strategic development program. And this is not only since control is the most important function of university management, providing all levels of information management necessary for making informed decisions and evaluating their effectiveness [2].

Internal monitoring can be defined as a regularly managed process through which the university management and all stakeholders receive information about progress in achieving the goals and objectives of the strategic development program. The organization of monitoring allows not only to track the implementation of planned actions but also to measure and analyze progress in achieving the program implementation targets (Fig. 1).

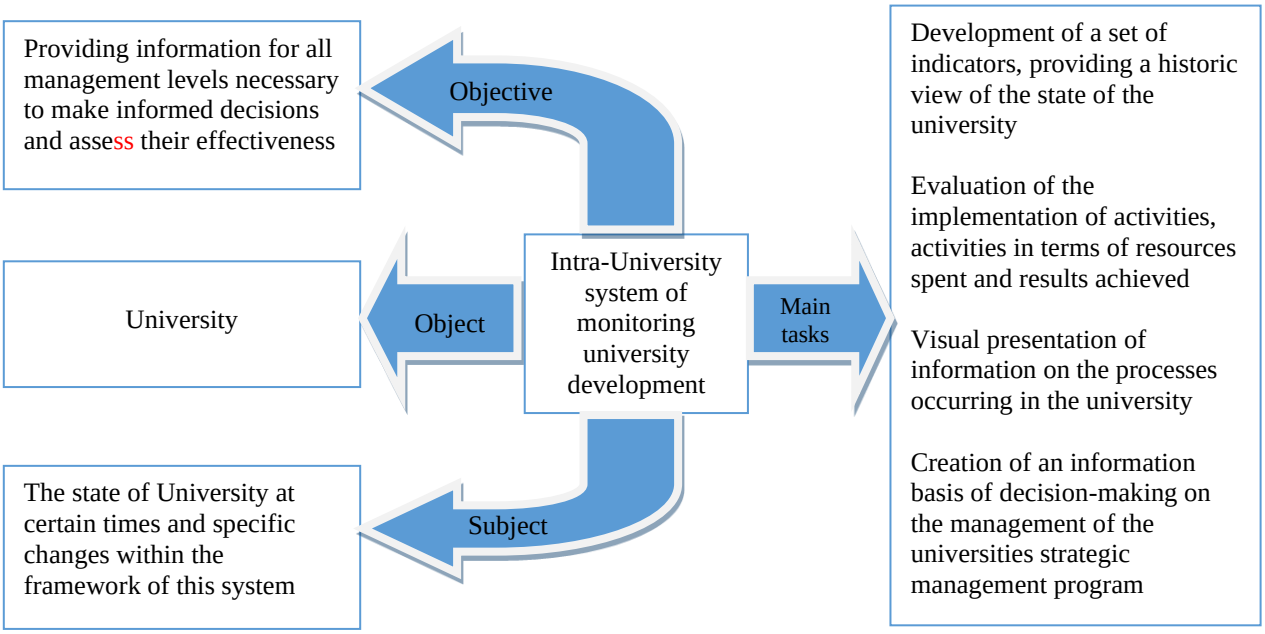


Figure 1. University development monitoring Concept

There are many arguments in favor of creating an internal monitoring system permanently. Monitoring allows to:

– better structure the key goals and objectives of the development program;

- translate the goals and objectives of the development program into the language e of target indicators, making them quantifiable;
- get important information about the progress of the development program in general;
- focus on results that help the university achieve its strategic goals;
- provide management with relevant information about whether or not there is a progress in achieving strategic goals;
- increase public confidence in the strategic development program and the university in general by ensuring transparency and accountability [3].

For monitoring as for managing the sustainable development of the university, the main thing is to analyze and reveal internal patterns, causes, and trends of processes. For monitoring to be effective, it needs to focus on those for whom this information is intended — decision-makers. The ultimate goal of monitoring is not to record the results of observation, but to make management decisions.

Developing a system of indicators is quite a time-consuming process. It is difficult to evaluate which factors are decisive in assessing the state of the university, and the significance of these factors may vary over time. As part of the current university development strategy, the system of indicators is considered in the context of four main areas that characterize the university activities such as academic activities, scientific activities, infrastructure development, and international cooperation.

## III. RELATED WORKS

New information computer technologies (ICT) based on learning technologies can increase the speed of perception, understanding, and depth of assimilation of a huge array of knowledge. The use of ICT has led to the fact that in computer technologies, inexhaustible opportunities are open for research at a qualitatively new level. In most educational institutions, there are no specialists in the development and operation of information systems, and insufficient experience and qualifications are noted among teaching and management personnel in the use of information technologies. New learning opportunities and new technologies require a high degree of preparation and application of ICT achievement. Issues of developing an information model for monitoring the development of higher education institutions were discussed in [4-7]. The study [8] focuses on the fact that the design of information technologies in education is changing the education system in general. Applying the principles of Industry 4.0 in the tasks of the educational process increases the effectiveness of monitoring the information and educational environment of the university [9]. The article [10] examines the fields of university activities in the context of quality assurance. The university strategy includes the necessary level of results in relation to inputs and processes. Currently, universities determine their strategy based on calculating their position in the market, which is the main source for comparative rating agencies, on internationalization carried out in university processes, and on calculating the impact of universities on the locality or region. Ensuring the quality of education has become a necessary prerequisite for the accreditation process, as well as a position in the rating.

The paper [11] substantiates the importance of creating an information and educational environment of a university, as well as analyzes the results of formation and reveals the prospects for the development of an electronic educational environment. The development of a system for monitoring the information and educational environment of the university will allow identifying existing and potential academic problems of students at an early stage of training [13].

One of the tasks of monitoring the development of the university's scientific potential is the process of managing scientific grants. The paper [14] presents a study that defines the main tasks of managing research grants and the correlation of these tasks with the university's roadmap. The result of this research is a model of an information system for managing research grants, which is designed to support operational activities, including presentation, evaluation, monitoring, reporting, and the formation of a university research plan. Also, one of the tasks of managing the development of the university is to simplify interaction with students. The next task of monitoring the development of the university is to attract talented applicants who are interested in studying in the chosen field of science or specialty, and also provide good competition. The study [12] suggests an approach to the development of a unified digital information and communication system of the university, which integrates the digital resources of potential applicants. Any educational institution must monitor student satisfaction, which is an important part of the educational process and a tool for feedback with students, which makes a significant contribution to the process of managing the development of the university. To improve the effectiveness of monitoring the educational process, the authors of the study [15] proposed a system based on the use of cloud technologies, which integrates the main services following the tasks of the educational process. One of the main tasks of the educational process is the curriculum management processes that take into account various optimality criteria. To solve this problem, the authors of the study [16] developed a model for creating a curriculum for basic educational programs using various heuristic methods and optimal criteria. The optimality analysis of each of the received curriculum variants is determined by the values of the weight coefficients used in the procedure for calculating hierarchical optimality criteria.

Thus, the development of monitoring systems for the information and educational environment of the university improves the quality of higher education. The study [17] substantiates the importance of managing the educational process and monitoring the quality of education, which is solved by developing an effective university management system. The results of the study [18] showed that such

systems allow to reorganize internal quality indicators and provide high-quality vocational education.

Strategies for the development of informatization of the university are as following: the development of the unified network infrastructure, the introduction of the latest information technologies in the educational process, automation of financial and economic activities, document management, and monitoring of all university activities. One of the main tasks is to create an integrated information system of the university, organize the university's representation in the Internet information space, and provide modern electronic services for teachers and students.

In most higher education institutions in Kazakhstan, the management of the educational process of the university is supported by the "Platonus" system. This is an effective information system for supporting the management processes of the education system, which allows to fully automate the processes of the credit system of learning technology. The system has a centralized database that reflects all real events and processes of the university [19].

The corporate information system (CIS) for University management developed by al-Farabi Kazakh National University, is a comprehensive, flexible and scalable information system that allows to combine internal business processes of the university, monitor and analyze, manage key resources and services, thereby contributing to improving the quality of educational services and improving the efficiency of university management [20]. This CIS integrates data from the information systems "Univer", "Science", "1C", EDMS "Directum" and SCD "Perco". This development of KazNU named Al-Farabi has been commercialized and implemented in 10 universities in Kazakhstan.

"Univer" is a collection of structurally-organizational and thematically interconnected web documents presented by individual elements of the website that have common navigation, electronic means of interaction, and information resources of scientific and educational content aimed at certain categories of users.

"Science" is designed to automate accounting, analysis, and monitoring of the results of research and innovation activities of the university and its affiliated scientific organizations.

D. Serikbayev East Kazakhstan Technical University is one of the universities of Kazakhstan, which has its unified information educational environment represented by a software and hardware complex, which is an integration of two subsystems: the educational portal Dales of Knowledge and the information and software complex SPORTAL [21].

SPORTAL is designed to manage the educational process of the university and the organization of educational, scientific, and innovative activities, allowing to create and systematically develop a liberal model of online education, Web application-educational portal Dales of Knowledge.

Some higher education institutions in Kazakhstan successfully operate AIS "Sova" – an automated information system that makes it possible to automate credit, traditional, and distance learning systems [22].

In recent years, many universities in the CIS countries have implemented a comprehensive solution of 1C "1C: University prof", which allows to automate the accounting, storage, processing, and analysis of information about all processes of the university: admission to the university, training, tuition, production, and employment of graduates, calculation and load distribution of teaching staff, activities of educational-methodical departments and reporting, and management of research and innovation, additional and postgraduate education, certification of scientific personnel, a campus of the university, personal accounts (incoming, student, teacher) [23].This solution is a flexible system that can be easily modified and adapted to the specific business processes of each University.

The Hochschul-information-System eG (HIS) [24] provides support for higher education administrations in German universities. HISinOne is an integrated higher education management system that has been used in most German universities and colleges since the mid-1990s. The current generation of software meets new IT standards and uses a holistic approach: it is technically and functionally integrated and is a fully web-based solution with a service-oriented architecture that is independent of platforms and operating systems. HISinOne supports all major processes and structures in universities of any size and type of organization.

If we talk about the informatization of higher education in the United States, e-universities are no longer considered as innovative solutions for the country. For example, such as higher education institutions as Western Governors University, Harvard University, Stanford University, University of California and others have their Internet platforms that combine the educational processes of the University into a single public system.

Based on this review of existing information systems, we can conclude that there is no single universal system for monitoring the development of higher education institutions. Since the monitoring procedure and internal documents differ in structure in higher education institutions. It follows that the development of its information system is advisable since the university has already had its information system.

## IV. MONITORING INFORMATION SYSTEM

The special feature of the university as an object of strategic management is a high level of decentralization, the need to involve the maximum number of stakeholders in the strategy development process. Another feature of building a strategic management system is the need to collect a large amount of poorly structured information necessary for analyzing the current situation. These factors determine the prospects for using information technologies for information support of the process of monitoring the implementation of the university's strategic development plan.

As noted above, currently there are many ready-made solutions to information support of strategic management and monitoring on the information technology market, such

as "1C:University", "Science", "RedLab University", "Oracle Hyperion", HISinOne, etc. However, each system has its advantages and disadvantages (Fig. 2). These systems are based on different information models.

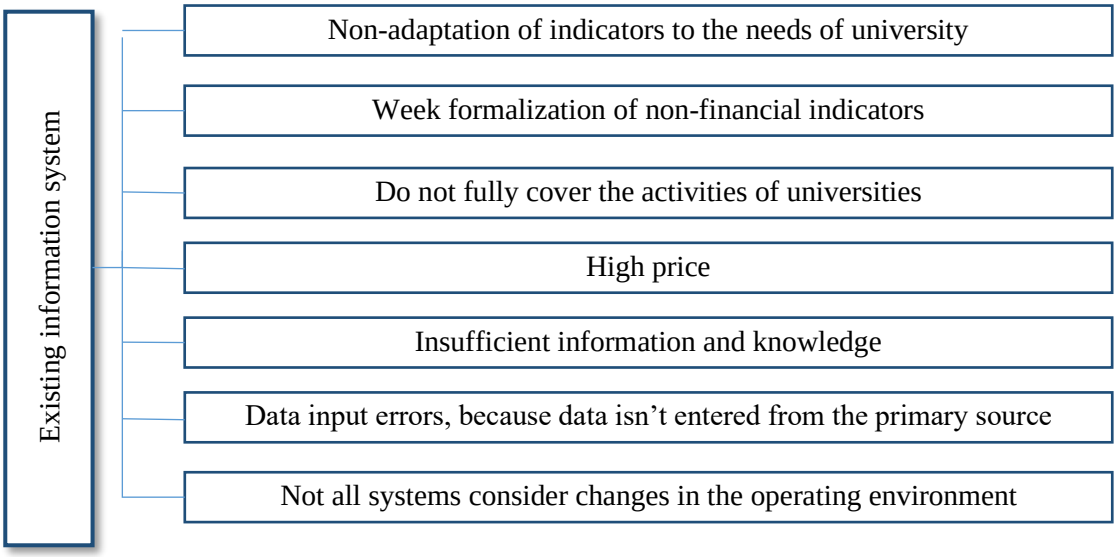


Figure 2. Disadvantages of existing information system

The lack of a ready-made unified universal system for solving the tasks of strategic management of universities, as well as the presence of already implemented accounting systems, makes it necessary to build an individual integrated solution for each specific organization [25]. As it was noted by D. Serikbayev, East Kazakhstan Technical University has its educational portal, which provides information support for academic and managerial activities. In this regard, it is important to develop an information model for monitoring the development of higher education institutions based on ontological models to expand the portal function.

Under these conditions, the use of an ontological approach to the development of an information monitoring system seems promising. In this case, the ontology will be used to form and fix the general knowledge shared by all experts about the subject area, its explicit conceptualization, which allows describing the semantics of data, ensuring the possibility of knowledge reuse, integration, and sharing of heterogeneous data and knowledge within a single system, and ensuring a better understanding of the subject area by users of the system [26, 27]. In this case, the ontology is a functional analog of the knowledge base that reflects the knowledge of experts about the subject area, i.e., the most important factors of the security domain are selected as nodes of the ontology graph, and cause-and-effect relationships between factors are selected as links [28].

An ontology is a structural specification of a specific subject area, its formalized representation including a dictionary (or names) pointers to domain terms and logical expressions describing how they relate to each other.

The ontology consists of terms (concepts), their definitions and attributes, as well as related axioms and rules of inference.

The proposed model describes the activities of the University:

$$O = \prec C, R, A \succ, \quad (1)$$

Where, C – is the set of concepts (classes) of the domain; R – is the set of relations between concepts; and A – is the set of axioms of the domain.

While developing an information model for monitoring the development of the University, two ontologies were identified:

– domain ontology;

– ontology of University management.

As the domain ontology, the SWRC (Semantic Web Research Community) ontological model was taken as the basis. The SWRC ontology generally models key actors related to typical scientific communities and the relationships between them. The current version of the ontology includes more than 70 concepts in the taxonomy and more than 70 properties of the objects [29, 30]. In the model, existing classes fully describe the scientific activities of the university. The description of this model and the advantage of this model over other ontological models were in detail discussed in the paper [30]. The ontology was supplemented with classes, properties, and rules for describing the management of students' research work.

An ontological model built around indicators of the subject area of concepts allows to achieve conceptualization of business processes that are aligned with the university's strategy, which should be covered, presented, distributed and processed by people and software systems.

The developed model is structured in several levels of decomposition with increasing depth and complexity. The

first level of our ontology contains the following classes: Objective, Vector, Indicator, and Measure. The first level is marked with a dotted line and the second level is marked with a solid line, as shown in Fig. 3.

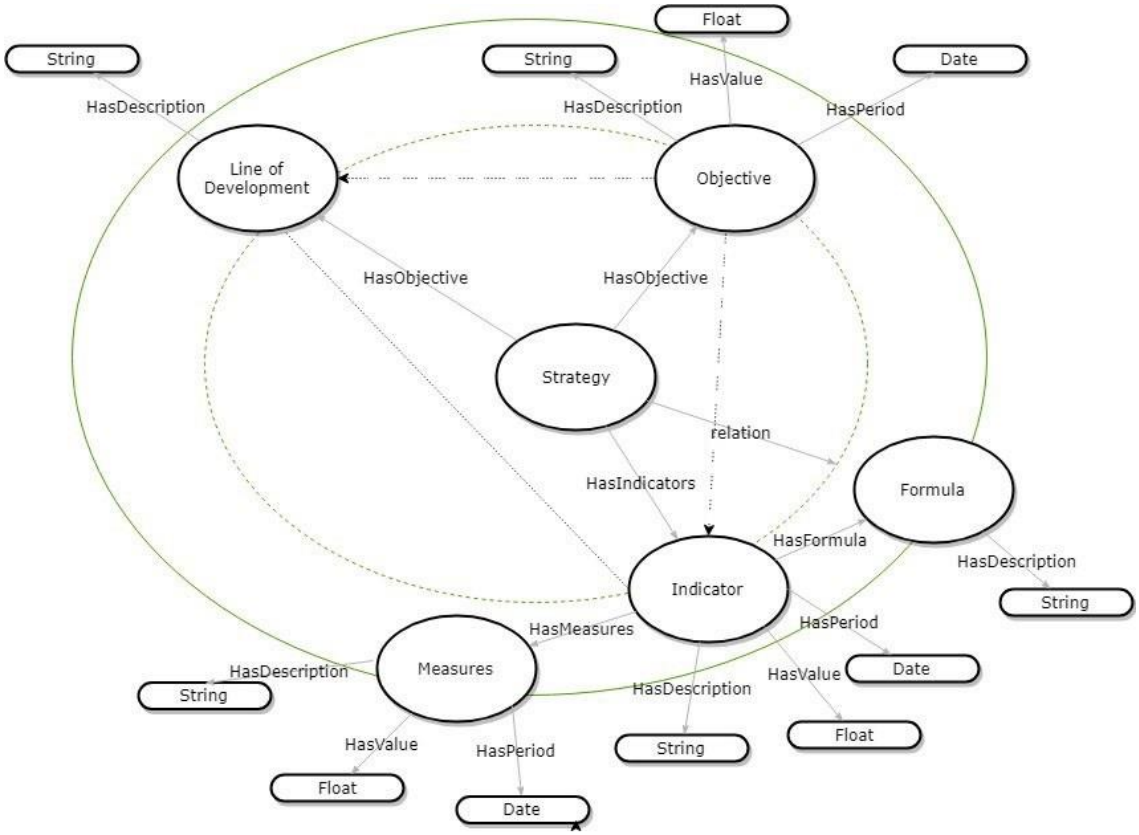


Figure 3. Ontological model of university management

One of the most important classes is Indicator. The representation of this class takes into account the relationship not only with the indicators (Measure) that are used in the calculation of the indicator, but also the indicators associated with these indicators. A more complete knowledge of the origin of the data involved in calculating the indicator can create a basis for more accurate comparison of indicators and better understanding of its meaning.

## V. CASE STUDY

The proposed model is used to represent indicators, the calculation of which is accompanied by inaccuracies and uncertainties. The article provides an example of calculation and analysis of the indicator "% of doctoral students defended in time". This indicator is calculated using formula (2):

$$I_1 = 100\frac{X_3}{X_1}, \qquad (2)$$

where $I_1$ is the percentage of doctoral students who submitted their doctoral dissertation on time; $X_1$ is the total number of grant by specialty, $X_3$ is the number of doctoral students who presented doctoral thesis in time.

Monitoring involves not only removing the values of indicators and calculating indicators, but also analyzing and developing corrective actions based on the analysis. According to experts, the value of this indicator can be influenced by many indicators (factors), which are shown in Fig. 4 and Table 1. This ontological model allows to select indicators that adapt to each situation. Fig.4 shows a fragment of the ontological model for the concerned indicator $I_1$. The ontology describes the properties of the indicator. Each indicator has a name, full description, calculation formula and a list of factors that affect the value of the indicator.

In the example, the data is taken for one Department for 5 years. We could simply compare the values of the indicators and make a conclusion about the dynamics of changes in the indicator value, taking into account the influence of the values of the indicators involved in the calculation (reducing the number of grants proportionally reduces the indicator value). But we can make a deeper analysis using all these indicators in order to reveal internal patterns, identify the reasons for not achieving the target value, and thereby create conditions for making management decisions.

For a complete description of the indicators, the SWRC

ontological model with additions was used. Further, the descriptive logic of ALC (Attributive Language with Complement) was applied to conduct the analysis in order to reveal the internal patterns and dependencies [31].

Composite concepts of logic:

– every atomic concept is a concept;

– if C is a concept, then its complement ¬ C is a concept;

– if C and D are concepts, then their intersection C ⊓ D and their union C⊔ D are concepts;

– if C is a concept and R is a role, then the expressions $\forall R.C$ and $\exists R.C$ are concepts.

The axiom of subsumption of concepts- $C \sqsubseteq D$, the axiom of equivalence of concepts – $C \equiv D$, where C and D are arbitrary concepts. Similarly, the axiom of subsumption of roles. The ⊑ symbol is a symbol of subsumption [32].

Concepts (Classes):

O – Organization;

P – Person;

PhDS –PhD Student;

PhDG – defended;

AS –Academic Staff;

SS – Scientific Supervisor;

C – Curriculum;

D – Document;

A – Article;

IP – InProceedings;

Pr –Project;

IR – Information recourse;

SD – Science Division;

IC – International cooperation;

RSS – Requirements to Scientific Supervisor;

RPhDSt – Requirements to PhD Student;

RPhDPr – Requirements to PhD program.

Roles (Relationships):

learningCurriculum – mastering the educational program;

hasScientificSupervisor – has a scientific advisor;

publisher – published;

editor – is the author;

worksAtProject – works in the project;

hasIntCooperetion – has international treaties;

hasMember – is a member;

hasRequirements – includes requirements;

cooperationWithOrganization – agreement with organizations;

hasDiv –belong to a division of science.

We will present the description of concepts and roles using a set of terminological axioms or TBox.

Axioms of concepts and roles:

An individual from the PhD Student class has an educational program to master:

$$PhDS_i \sqsubseteq P \sqcup \exists learningCurriculum.C \quad (3)$$

Each defended graduate of the educational program must master the educational program and fulfill the requirements specified in the regulation:

$$PhDS_i \sqsubseteq P \sqcup \exists learningCurriculum.C \sqcup \exists hasRequirements.RPhDPr \quad (4)$$

An individual from the Scientific Supervisor class is an employee of the university and must meet the requirements for scientific consultants:

$$SS_i \sqsubseteq P \sqcup \exists hasRequirements.RS \quad (5)$$

The publications, that scientific consultants and students should have, refer to a document, published by a person, which meets certain requirements and is semantically close to the research topic:

$$\begin{gathered} A_i \sqsubseteq Document \sqcup \exists Publisher.P \sqcup \exists hasIR.IR \\ IP_i \sqsubseteq Document \sqcup \exists Publisher.P \sqcup \exists hasIR.IR \\ IR_i \equiv \forall\ hasDiv.SD_{(i)} \end{gathered} \quad (6)$$

Scientific projects are defined as:

$$Pr_i \sqsubseteq \exists hasMember.P \sqcup \exists hasDiv.SD \quad (7)$$

International cooperation agreements are agreements concluded with third-party organizations of education, science or industry:

$$\begin{gathered} IC_i \sqsubseteq \exists cooperationWithOrganization.O \\ \sqcup \exists hasDiv.SD \end{gathered} \quad (8)$$

The presented axioms of concepts and roles (3)-(8) were used to assess the adequacy and productivity of students and scientific advisers.

The conducted research of the values of indicator $I_1$ and current values factors for 2015-2019 (Table 1) leads to the following conclusions. The influence of these factors to the final value of the indicator $I_1$ is established. The values of $X_2$, $X_4$, $X_7$ don't have influence on the $I_1$ indicator value. The values of $X_5$, $X_6$, $X_8$ affect the final result of the $I_1$ indicator. The relationship between indicator and factors are established based on the study of the actual values of the factors using the rules described above.

**Table 1. Values of indicators**

| Indicators | Years | | | | |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| **X1** | 2 | 2 | 2 | 2 | 3 |
| **X2** | 2 | 2 | 2 | 2 | 3 |
| **X3** | 2 | 0 | 2 | 0 | 1 |
| **X4** | 4 | 3 | 2 | 1 | 1 |
| **X5** | 8 | 7 | 6 | 6 | 8 |
| **X6** | 4 | 4 | 7 | 5 | 6 |
| **X7** | 4 | 4 | 4 | 3 | 3 |
| **X8** | 6 | 4 | 2 | 0 | 0 |

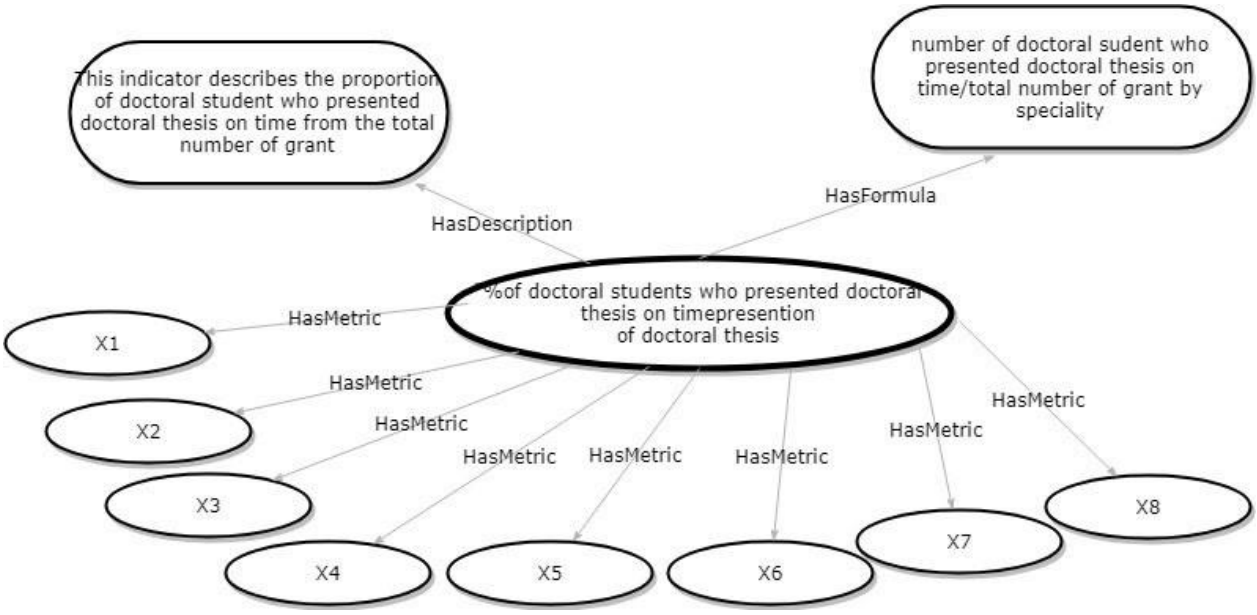


Figure 4. Indicator ontology. There, X1 – total number of grant by specialty; X2- number of doctoral students who graduated theoretical course; X3- number of doctoral students who presented doctoral thesis on time; X4 – number of research projects; X5 – number of articles indexed in scientific DB, X6 – number of articles and conspectus in Conference Proceeding; X7 – International co-operation; X8 – number of invited professors.

Based on the data obtained as a result of the study, it is possible to formulate recommendations for the development and adjustment of strategies and a development plan. Thus, the implemented model supports feedback on the assessment of the strategic plan and the development of corrective actions aimed at reducing the deviations of the actual values of development indicators from the planned ones.

This use case demonstrated the importance of considering a set of information when comparing indicators/indicators. We have demonstrated that ontologies can represent the background by increasing the semantics and accurately positioning the indicator in its area, reducing blurring and giving an improved understanding of the measurement background.

## VI. CONCLUSION

In a modern university, information becomes one of the mandatory components of management processes, since its production, transmission and consumption forms a kind of "Foundation" for the effective functioning of all fields of society. The result of the education system's activity largely depends on the correctness of the formation and adequacy of the use of information flows. Currently, as noted in the article, Kazakhstan does not have a unified information system with an optimal structure for all universities, their architecture, functions that they implement, and approaches to data security have not been developed taking into account the specifics of educational institutions. Given the advantages and disadvantages of existing models, an information model for monitoring university development was proposed based on an ontological approach with an emphasis on the presentation of indicators/indicators with the possibility of comparison between two or more. The article provides an example of calculating only one indicator, analyzing the impact of indicators on the value of this indicator, and the relationship of indicators. The results obtained will make it possible to make management decisions and improve the university management policy.

The model in further detail can be the basis for reengineering, based on it it's possible to form the informatization strategy of the university, to optimize the work of structural units, to determine the potential of information technology to improve the efficiency of the university in general that will serve as the basis for competitiveness of the university on the educational services market.

## References

[1] B. Jongbloed, J. Enders, C. Salerno, "Higher education and its communities: Interconnections, interdependencies and a research agenda," *Higher Education*, vol. 56, issue 3, pp. 303–324, 2008, https://doi.org/10.1007/s10734-008-9128-2.

[2] T. Lendyuk, S. Rippa, O. Bodnar and A. Sachenko, "Ontology application in context of mastering the knowledge for students," *Proceedings of the 2018 IEEE 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies (CSIT'2018)*, Lviv, 2018, pp. 123-126, https://doi.org/10.1109/STC-CSIT.2018.8526710.

[3] G. Fernandes, R. J. Machado, E. B. Pinto, M. Araujo and A. Pontes, "A quantitative study to assess a program and project management approach for collaborative university-industry R&D funded contracts," *Proceedings of the 2016 International Conference on Engineering, Technology and Innovation/IEEE International Technology Management Conference (ICE/ITMC)*, Trondheim, Norway, 2016, pp. 1-10, https://doi.org/10.1109/ICE/ITMC39735.2016.9026093.

[4] M. S. A. Silva, C. G. da Silva. Lima, "The role of information systems in human resource management," *Management of Information Systems*, 2018, pp. 113-126, https://doi.org/10.5772/intechopen.79294.

[5] B. Abazi-Çaushi, Z. Dika, "Higher education information systems: An overview of the latest trends and issues," *Proceedings of the VIIIth Annual International Meeting of Alb-Science Institute*, Tirana, Albania, August 29-31, 2013.

[6] Y. Li et al., "Design of higher education quality monitoring and evaluation platform based on big data," *Proceedings of the 12th International Conference Computer Science and Education (ICCSE)*, Houston, USA, August 22-25, 2017, pp. 337-342, https://doi.org/10.1109/ICCSE.2017.8085513.

[7] A. AlRababah, A. AlShahrani, B. Al-Kasasbeh, "Efficiency model of information systems as an implementation of key performance indicators," IJCSNS International Journal of Computer Science and Network Security, vol. 16, no. 12, pp. 139-143, 2016.

[8] I. Guitart, & J. Conesa, "Creating university analytical information systems," in book: *Formative Assessment, Learning Data Analytics and Gamification*, pp.167–186, 2016, https://doi.org/10.1016/B978-0-12-803637-2.00009-9.

[9] O. Meski, F. Belkadi, F. Laroche, & B. Furet, "Towards a knowledge-based framework for digital chain monitoring within the industry 4.0 paradigm," *Proceedings of the 29th Procedia CIRP*, Portugal, 2019, pp. 118–123, https://doi.org/10.1016/j.procir.2019.04.250.

[10] T. Čorejová, T. Genzorová and M. Rostášová, "On the university strategy in the education quality assurance: Case study," *Proceedings of the 2017 16th International Conference on Information Technology Based Higher Education and Training (ITHET)*, Ohrid, 2017, pp. 1-4, https://doi.org/10.1109/ITHET.2017.8067795.

[11] E. K. Semarkhanova et al., "Information technologies as a factor in the formation of the educational environment of a university," *Proceedings of the International Conference on Humans as an Object of Study by Modern Science*, Springer, Cham, 2017, pp. 179-186, https://doi.org/10.1007/978-3-319-75383-6_23.

[12] J. Effah, "Virtual process control modelling in organisational semiotics: A case of higher education admission," *Proceedings of the Information and Knowledge Management in Complex Systems (ICISO'2015), IFIP Advances in Information and Communication Technology*, vol. 449, Toulouse, France, March 19-20, 2015, pp. 51-59, https://doi.org/10.1007/978-3-319-16274-4_6.

[13] S. Maslovskyi and A. Sachenko, "Adaptive test system of student knowledge based on neural networks," *Proceedings of the 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS'2015)*, Warsaw, 2015, pp. 940-944, https://doi.org/10.1109/IDAACS.2015.7341442.

[14] A. S. Perbangsa et al., "Research grants management information systems model," *Proceedings of the 2016 IEEE International Conference on Information Management and Technology (ICIMTech)*, 2016. pp. 247-252, https://doi.org/10.1109/ICIMTech.2016.7930338.

[15] O. I. Chuyko, "Development of an information system for organizing and monitoring the educative process of students on the basis of cloud technologies," Proceedings of the 2019 IEEE International Science and Technology Conference "EastConf", 2019, pp. 1-5, https://doi.org/10.1109/EastConf.2019.8725342.

[16] MacCarthy B.L., Pasley R.C., "Decisions as Units of Organizational Knowledge to Manage Complexity," in: Świątek J., Borzemski L., Grzech A., Wilimowska Z. (eds) *Information Systems Architecture and Technology: Proceedings of 36th International Conference on Information Systems Architecture and Technology – ISAT 2015 – Part III. Advances in Intelligent Systems and Computing*, vol 431. Springer, Cham, pp. 153-161, https://doi.org/10.1007/978-3-319-28564-1_13.

[17] Z. Liu, G. Shanshan and S. Yuan, "Research on teaching process management and quality monitoring system for higher education," *Proceedings of the 2019 10th International Conference on Information Technology in Medicine and Education (ITME)*, Qingdao, China, 2019, pp. 485-489, https://doi.org/10.1109/ITME.2019.00114.

[18] T. Corejova, M. Rostasova, R. Chinoracky, "Self-assessment as a tool for quality management of an educational institution in a technology-rich environment," *Proceedings of the 2019 18th International Conference on Information Technology Based Higher Education and Training (ITHET)*, 2019, pp. 1-6, https://doi.org/10.1109/ITHET46829.2019.8937342.

[19] Platonus University, [Online]. Available at: https://platonus.kz/en/produkty/7-platonus-university

[20] Strategic infrastructure Kazakh National university Al-Farabi, [Online]. Available at: https://it.kaznu.kz/?page_id=293

[21] Dales of Knowledges, [Online]. Available at: https://www.do.ektu.kz/dales.htm

[22] Winanti, Meyliana, A. N. Hidayanto, H. Prabowo, F. L. Gaol, "Key successful factors of executive information system implementation in higher education: A systematic literature review," *Proceedings of the 2018 International Conference on Information Management and Technology (ICIMTech)*, Indonesia, 3-8 September 2018, pp. 423-427, https://doi.org/10.1109/ICIMTech.2018.8528124.

[23] Opportunity of 1C: University PROF https://solutions.1c.ru/catalog/university-prof/features

[24] Hochschul-Informations-System GmbH (HIS), [Online]. Available at: https://www.eurashe.eu/about/partners/his/

[25] M. Z. Bazarova, G. Zhomartkyzy, W. Wojcik, Y.V. Krak, "Construction of individual trajectories of training specialists in the field of information and communication technologies," *Journal of Automation and Information Sciences*, vol. 49, issue 10, pp. 36-46, https://doi.org/10.1615/JAutomatInfScien.v49.i10.40.

[26] M. Penha, W.F.M. Correia, "Usability recommendations for a learning management systems (LMS) – A case study with the LMS of IFPE," in: Ahram T., Falcão C. (eds) Advances in Usability, User Experience and Assistive Technology. AHFE 2018. Advances in Intelligent Systems and Computing, vol 794. Springer, Cham, 2018. pp. 451–460, https://doi.org/10.1007/978-3-319-94947-5_46.

[27] G. Zhomartkyzy, T. Balova, "The development of information models and methods of university scientific knowledge management," Springer International Publishing Switzerland, S. Hammoudi et al. (Eds.): ICEIS 2015, LNBIP 241, pp. 429–451, 2015, https://doi.org/10.1007/978-3-319-29133-8_21.

[28] O. V. Barmak, O. V. Mazurets, Iu. V. Krak, A. I. Kulias, L. E. Azarova, K. Gromaszek, S. Smailova, "Information technology for creation of semantic structure of educational materials," *Proc. SPIE 11176, Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments*, 2019, 1117623, https://doi.org/10.1117/12.2537064.

[29] Y. Sure, S. Bloehdorn, P. Haase, J. Hartmann, D. Oberle, "The SWRC ontology – Semantic web for research communities," *Proceedings of the Portuguese Conference on Artificial Intelligence (EPIA)*, Portugal, 2005, pp. 218–231, https://doi.org/10.1007/11595014_22.

[30] L. Suleimenova, G. Zhomartkyzy, S. Kumargazhanova, "Integration data models based on ontology," *Proceedings of the 5th International Conference on Engineering and MIS (ICEMIS'2019)*, Kazakhstan, 2019, pp. 1-5, https://doi.org/10.1145/3330431.3330438.

[31] K. Britz, G. Casini, T. Meyer, I. Varzinczak, "A KLM perspective on defeasible reasoning for description logics," in: Lutz C., Sattler U., Tinelli C., Turhan AY., Wolter F. (eds) *Description Logic, Theory Combination, and All That. Lecture Notes in Computer Science*, vol. 11560. Springer, Cham., 2019, pp. 147-173, https://doi.org/10.1007/978-3-030-22102-7_7.

[32] F. Baader, D. Calvanese, L. McGuinness, D. Nardi and P. F. Patel-Schneider, *The Description Logic Handbook: Theory, Implementation, and Applications*, Cambridge University Press, 2003.


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