DOI 10.54596/2958-0048-2024-4-204-212
UDK 004.378
IRSTI 82.05.09

TOWARDS THE DEVELOPMENT OF A DECISION-MAKING SYSTEM FOR INDICATIVE PLANNING IN HIGHER EDUCATION INSTITUTIONS

Iklassova K.[1*]
[1]Manash Kozybayev North Kazakhstan University NPLC, Petropavlovsk, Kazakhstan*
[*]Corresponding author: keiklasova@ku.edu.kz

Abstract

This study explores the development of decision-making methods for indicative planning within higher education institutions (HEIs). In the context of globalization and digital transformation, the ability to make informed management decisions is crucial for the success of HEIs. The research focuses on creating a system that improves decision quality by employing indicative planning and systemic-cognitive analysis. Indicative planning allows for the systematic organization of decisions by forecasting outcomes and optimizing strategies. Systemic-cognitive analysis provides a comprehensive tool for modeling complex decision-making processes, enhancing the transparency and effectiveness of management. The study identifies both strengths and limitations of these methods, suggesting improvements such as the integration of machine learning to enhance adaptability. The proposed approach aims to create a flexible, adaptive decision support system that can rapidly respond to changes in the educational environment, ultimately contributing to more efficient and effective management in HEIs.

Keywords: Decision-Making, Indicative Planning, Higher Education Institutions (HEIs), Systemic-Cognitive Analysis.

ЖОҒАРЫ ОҚУ ОРЫНДАРЫНДА ИНДИКАТИВТІ ЖОСПАРЛАУ БОЙЫНША ШЕШІМ ҚАБЫЛДАУ ЖҮЙЕСІН ҚҰРАСТЫРУ БАҒЫТЫНДА

Икласова К.[1*]
[1]«Манаш Қозыбаев атындағы Солтүстік Қазақстан университеті» КеАҚ*
Петропавл, Қазақстан
[*]Хат-хабар үшін автор: keiklasova@ku.edu.kz

Андатпа

Бұл зерттеу жоғары оқу орындарындағы (ЖОО) индикативтік жоспарлау үшін шешім қабылдау әдістерін әзірлеуге арналған. Глобализация және цифрлық трансформация жағдайында басқарушылық шешімдерді дұрыс қабылдау ЖОО-ның сәттілігі үшін маңызды фактор болып табылады. Зерттеу индикативтік жоспарлау және жүйелі-когнитивтік талдау арқылы шешімдердің сапасын жақсартатын жүйені құруға бағытталған. Индикативтік жоспарлау шешім қабылдау процесін жүйелеп, нәтижелерді болжау және стратегияларды оңтайландыру арқылы іске асырады. Жүйелі-когнитивтік талдау шешім қабылдау процестерін моделдеуге арналған кешенді құралды қамтамасыз етіп, басқарудың тиімділігі мен айқындығын арттырады. Зерттеуде бұл әдістердің артықшылықтары мен шектеулері анықталып, машиналық оқыту әдістерін енгізу сияқты жақсартулар ұсынылған. Ұсынылған тәсіл білім беру ортасындағы өзгерістерге тез жауап бере алатын икемді және бейімделгіш шешім қабылдау жүйесін құруға бағытталған, бұл ақыр соңында ЖОО-ларда тиімді басқаруды қамтамасыз етеді.

Кілт сөздер: шешім қабылдау, индикативті жоспарлау, жоғары оқу орындары (ЖОО), жүйелік-когнитивті талдау.

К ВОПРОСУ РАЗРАБОТКИ СИСТЕМЫ ПРИНЯТИЯ РЕШЕНИЙ ДЛЯ ИНДИКАТИВНОГО ПЛАНИРОВАНИЯ В ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ

Икласова К.[1*]

[1*]*НАО «Северо-Казахстанский университет имени Манаша Козыбаева»*
Петропавловск, Казахстан
[*]*Автор для корреспонденции: keiklasova@ku.edu.kz*

Аннотация

Данное исследование посвящено разработке методов принятия решений для индикативного планирования в высших учебных заведениях (ВУЗах). В условиях глобализации и цифровой трансформации способность принимать обоснованные управленческие решения становится ключевым фактором успеха ВУЗов. Исследование направлено на создание системы, улучшающей качество решений, посредством применения индикативного планирования и системно-когнитивного анализа. Индикативное планирование позволяет систематизировать процесс принятия решений, прогнозируя результаты и оптимизируя стратегии. Системно-когнитивный анализ предоставляет комплексный инструмент для моделирования сложных процессов принятия решений, повышая прозрачность и эффективность управления. В работе выделяются как сильные стороны этих методов, так и их ограничения, предлагаются улучшения, такие как интеграция методов машинного обучения для повышения адаптивности. Предлагаемый подход направлен на создание гибкой адаптивной системы поддержки принятия решений, способной быстро реагировать на изменения в образовательной среде, что в итоге способствует более эффективному управлению в ВУЗах.

Ключевые слова: Принятие решений, индикативное планирование, высшие учебные заведения (ВУЗы), системно-когнитивный анализ.

Introduction

In today's environment, when educational institutions face many challenges related to globalization and digital transformation, making informed and effective management decisions becomes a key factor in the successful functioning of HEIs. In this regard, the introduction of methods that allow systematizing and optimizing the data-driven decision-making process is of particular importance.

The aim of this study is to develop and implement an indicative planning system aimed at improving the quality of management decisions in educational institutions. The main objectives are to analyses the existing methods of decision support, to develop a model of indicative management, and to assess its effectiveness in the context of a specific educational institution.

The relevance of this work is determined by the need to improve the quality of management decisions in conditions of high dynamics of the external environment and growing complexity of educational processes. The novelty of the research lies in the application of system-cognitive analysis approaches to create a model that can support the decision-making process at different levels of university management.

Research results

Forecasting. An indicative plan serves as a forecast tool, aiding economic entities, including educational institutions, in developing their own strategies based on future projections provided by government and scientific organizations. Modern research [1-11] explores educational quality, fostering professional forecasting among university students, and strategic management in education. Forecasting is crucial in planning, as it minimizes risk and uncertainty in decision-making by setting guiding indicators that define the system's sustainable functioning and development [12], «the quality of which is largely determined by the

composition, completeness and representativeness of the indicator system. The apparatus of system-cognitive analysis ensures the universality of indicative planning procedures through multivariant situational analysis; various forms of obtaining and presenting information» [13], «aggregated accounting of the influence of exogenous/endogenous factors on the institutional structures of education.

Considering the HEI as a representative of the institutional structure of education, it should be noted that the planned solution, as a subject of indicative planning, assumes two groups of characteristics:

desired HEI states (indicators);

ways to achieve these states (reactions - parameters of control actions aimed at achieving the indicators).

Cognitive modelling of problems of weakly structured complex systems, declaring the principle of interdisciplinarity, assumes a unified system of models, methods (including *statistical* methods) and information technologies from different branches of knowledge to solve a number of problems (including object *identification, forecasting*)» [13].

Cognitive modelling. The system paradigm declares education as a complex socio-economic, organizational, active, «dynamic system that provides information exchange between individuals, various forms of their associations and the world community as a whole. Being a system that unites institutional structures (preschool educational institutions, schools, universities, additional/postgraduate education, etc.), education itself is a subsystem/element of a higher-order system - society as a whole.

So, education is complex:

- is identified by goals, functions and outcomes that are self-consistent according to the goals, objectives and standards of a particular society, i.e. education is subjectively constructed and is a managed process;
- actively influences the development and stability of institutional structures,
- i.e. is considered in the context of objectively existing reality.

Thus, the solution of education problems (education management) occurs not only at the level of the educational system itself, but also is a component of the state policy» [14].

«The instrument of state indirect regulation of the functioning and development of the educational system is indicative management» [15].

The methodology of multidimensionality and the fractal structure of the educational system views indicative management as a tool for the state's indirect regulation of education. This approach helps coordinate actions between public authorities and educational institutions, aiming to promote sustainable development and improve education quality [16}

It is the recommendatory nature of the indicative plan (vertically integrated system of hierarchy of management levels) that allows the *formation of development plans* by the lower levels of the hierarchy of institutional structures.

The methodology of indicative planning in the field of education is characterized by a number of features: unevenness of information and communication processes; objectively delayed nature of management; inertia and weak controllability as a result of non-linear development due to innovations; weak stability as a consequence of unstable trends in the development of educational services market needs; uncertainty in the description of facts and events of educational processes and many others [17].

The apparatus of system-cognitive analysis provides universality of indicative planning procedures by means of:

- multivariate situational analysis;

– different forms of obtaining and presenting information;
– aggregate accounting of the influence of exogenous/endogenous factors on the institutional structures of education.

The result of systemic cognitive analysis is knowledge:
– the consistency of the envisaged objectives (set of problems to be solved);
– the existence of possible control actions (measures), the implementation of which allows, in principle, to achieve all the intended objectives.

The analytical technology of cognitive modelling is based on cognitive (cognitive-targeted) structuring of knowledge about the object and its external environment, and the object and the external environment are distinguished «vaguely» [18].

Expert evaluations. Modern research offers various approaches to the formation of the system of enterprise performance indicators.

Many of the techniques designed for financial organizations focus on financial analysis. Works like [20, 21] review methods for developing indicator systems, such as A.V. Pismarov's method and the balanced scorecard «MAG CONSULTING» [23]. These methods offer advantages like combining financial and non-financial indicators, linking efficiency to strategy, and providing a comprehensive view of activities. However, they also have drawbacks: insufficient cause-effect analysis, poor indicator balancing, and weak strategy alignment. Due to these limitations and their economic efficiency focus, these methods aren't ideal for developing indicators for HEIs.

HEI efficiency requires more than financial metrics; educational, scientific, and international activity indicators are essential. Early studies [24] analyzed balanced scorecards across universities but didn't detail development methods. Some research [25] extended traditional indicators by considering stakeholder management benefits, while others [26] highlighted common strategic planning flaws, such as missing quantitative indicators. Papers like [27] introduced economic models considering strategic goal achievements, while [28] and [29] developed new indices for comparing innovation and benchmarking job satisfaction across sectors.

At the University of Cienfuegos, a methodology [30] for aligning strategy with management was applied. Subsequent studies [31] discussed information systems for controlling university activities, focusing on indicators aligned with indicative plans, formalization, and analytics design. These indicators serve as inputs for systems like «Indicative Planning» [32].

The *entropy approach* has been considered in works on decision making [33-37], resource utilization in higher education [38], curriculum improvement [39], university faculty evaluation [30], and information literacy assessment [41].

Let us consider the functioning of socio-economic system on the example of a higher education institution. Let us position the monitoring of the indicative plan as a process for which it is necessary to calculate quantitative characteristics of information. These characteristics can be reflected in the entropy estimation of the set of documents required for monitoring and determined by the amount of information that supports management decision making [42]. Indicative management implies monitoring of indicative indicators; comparison of forecast data and target indicators; evaluation and selection of the most successful development alternatives and effective decision-making options [43].

To effectively implement indicative management, it is essential to establish a robust system that can handle the complexities of the socio-economic environment in higher education institutions. This system must be capable of dynamically processing and analyzing vast

amounts of data to provide meaningful insights, thus supporting the decision-making process. The system's design should facilitate the continuous evaluation of development strategies, ensuring alignment with long-term institutional goals.

By the nature of interaction with the user this system belongs to the type of passive systems, i.e. helping in the decision-making process, but not putting forward specific solutions. By the way of support, the developed system is model-oriented, as well as aimed at processing unstructured information and perform dynamic modelling of processes. By the sphere of use SPPR is desktop, to ensure the work of senior managers, providing a strategic level of management. The development of management decisions at this level should take into account the dynamics of the implementation of decisions, as the results of decisions are manifested in significant time intervals.

The software The creation of decision support systems, in the classical form, includes four main components: mathematical models and analytical tools, databases, user interface and network. The architecture of the developed DSS follows a traditional approach, with the analytical tools block as the main component. In the context of indicative management, this block is designed to present information clearly, cost-effectively, and to facilitate user interaction with the system. It ensures efficient analysis, processing, and utilization of information to support decision-making.

The main requirements for the functionality of decision support software:

- providing input, storage, actualization of information received from both external and internal environments of the system;
- structuring of information through the creation of a database;
- integration with the organization's existing information system.
- The key programmer modules of the indicative management decision support system are:
- module of support of the process of formation of the indicative plan indicator system;
- module of decision-making support by means of modelling the variant of the indicative plan;
- module of assessment of the effectiveness of the developed decisions on indicative planning.

Discussion

The study considers the methods of indicative planning and system-cognitive analysis for creating decision support systems in educational institutions. These methods play a key role in structuring and improving management processes. Let us consider them in more detail.

Indicative planning.

Optimizing decision-making: Indicative planning helps to systematize management decisions, allowing managers to assess the consequences of different scenarios in advance and choose the most optimal strategies.

Building predictive systems: This method supports the development of systems capable of predicting the outcomes of management decisions, which reduces risk and improves the quality of management of educational institutions.

Simplifying processes: Introducing indicative planning helps automate decision-making processes, which reduces the burden on managers and minimizes the impact of the human factor. Weaknesses:

Lack of adaptability: Despite its advantages, indicative planning may not be flexible enough in environments that require immediate decision-making. This limits its applicability in situations of high uncertainty.

Data dependency: The effectiveness of indicative planning depends directly on the quality and completeness of the input data. Insufficiently accurate data can lead to wrong decisions.

Suggestions for improvement:

Integrating machine learning techniques to improve adaptability and create predictive models that can learn from new data and adapt quickly to change.

Developing more flexible decision support systems that can combine elements of indicative planning with other approaches to improve the speed and accuracy of management actions.

Systemic cognitive analysis.

Integrated Decision Support: Systems Cognitive Analysis provides a comprehensive tool for modelling complex decision-making processes, helping managers to consider multiple factors and their interactions.

Cognitive systems development: This method facilitates the creation of cognitive models that can be used in information systems to support decision-making. Such models make it possible to predict the consequences of different management decisions and identify the most effective strategies.

Interpretability of complex data: The cognitive maps generated by this approach visualise the relationships between different parameters, making the decision-making process more transparent and informed.

Weaknesses:

High complexity: Systems cognitive analysis requires a significant intellectual and resource investment. Creating and interpreting cognitive models can be challenging for those without specialized knowledge.

Limited adaptability: Although cognitive models aid in decision making, their rigid structure can limit flexibility in situations that require rapid changes in approaches or model updates.

Suggestions for improvement:

Adopt adaptive cognitive systems that can automatically update based on new data and provide more flexible recommendations for decision-making.

Developing interfaces and training programmers to facilitate the use of cognitive models to make the method more accessible and understandable to a wide range of managers.

Conclusion

The approaches applied in the study significantly contribute to improving the decision-making process in the management of educational institutions. Indicative planning and systemic cognitive analysis not only structure the decision-making process, but also support the development of systems capable of predicting and optimizing the results of management actions.

To maximize their effectiveness, these methods can be integrated into flexible and adaptive decision support systems that consider the dynamism of the educational environment and allow for rapid response to change. In the future, it is important to consider the application of new technologies, such as artificial intelligence and machine learning, to create more advanced management decision support systems.

References:

1. Kuznetsova O.N., Maksimov V.Y., Narozhnaya G.A., Tkachenko A.E., Toiskin V.S. Approaches to Quality of Education that Conform to the Needs of Labour Market in Information Society // Perspectives

on the use of new information and communication technology (ict) in the modern economy. - 2019. - Vol. 726. - P. 1134-1143. DOI: 10.1007/978-3-319-90878-0_128
2. Kargapoltseva N.A., Erofeeva N.E., Pak L.G., Goriainova T., Popova O.V., Kulesh E.V., Ilkevich B.V. Creation Culture Of Occupational Forecasting For University Students // Modern journal of language teaching methods. - 2018. - Vol. 8, № 6. - P. 190-201.
3. Kuklin, A.A., Korobkov I., V Selection of an Effective Trajectory of Regional Socio-Economic Development // Ekonomika regiona-economy of region. - 2018. - Vol. 14, № 4. - P. 1145-1155. DOI: 10.17059/2018-4-18
4. Means A.J. Platform learning and on-demand labour: sociotechnical projections on the future of education and work// Learning media and technology. - 2018. - Vol. 43, № 3. - P. 326-338. DOI: 10.1080/17439884.2018.1472607
5. Ilchuk P., Mushenyk I. Influence of development of national innovation systems on the economic efficiency // Baltic journal of economic studies. - 2018. - Vol. 4, № 2. - P. 78-85. DOI: 10.30525/2256-0742/2018-4-2-78-85
6. Whittington R., Yakis-Douglas B., Ahn K., Cailluet L. Strategic Planners in More Turbulent Times: The Changing Job Characteristics of Strategy Professionals, 1960-2003 // Long range planning. - 2017. - Vol. 50, № 1. - P. 108-119. DOI: 10.1016/j.lrp.2016.07.002
7. Robertson S.L. Making education markets through global trade agreements // Globalisation societies and education. - 2017. - Vol. 15, № 3. - P. 296-308. DOI: 10.1080/14767724.2017.1330134
8. Titova N., Shutov A. Predictive model of strategic development of a university // 2nd International conference on information technology and quantitative management, itqm. - 2014. - Vol. 31. - P. 459-467. DOI: 10.1016/j.procs.2014.05.283
9. Ligonenko L.O. Theoretical and methodological foundations of technological management // Marketing and management of innovations. - 2016. - Vol. 3. - P. 145-160.
10. Kulikova V.P., Iklasova K.E. To the issue of forecasting indicative indicators // Bulletin of KazNITU. - Almaty, 2019. - №2 (132). - P. 256-261.
11. Dorgushaova A.K. Indicative planning of regional development. "Economic Library." http://economy-lib.com. 14.03.2019.
12. Kulikova V., Iklassova K., Kazanbayeva A. Development of a decision making method to form the indicators for a university development plan // Eastern-European Journal of Enterprise Technologies. – 2019. – №3/3 (99). – P.12-21.
13. Gorelova G.V., Zakharova E.N., Radchenko S.A. Research of poorly structured problems of socio-economic systems: a cognitive approach. - Rostov n/D: Izd vo RSU, 2006. - 332 p.
14. Kushlin V.I. Gosudarstvennoe regulirovanie rynochnoj ekonomiki: uchebnik / pod red. Kushlina V.I. – 2-e izdanie, dop. i perer. – M.: RGAS, 2005. – 825 p.
15. Karpova N.K. Methodology of indicative management of education system development as a tool for the implementation of socio-economic policy of the state., http://www.rusnauka.com. 14.03.2019.
16. Kravtsov S.S., Karpova N.K. Indicative planning and indicative management of development of modern education system: methodological aspect. https://www.sworld.com.14.03.2019.
17. Karpova N.K., Mareev V.I., Gaponyuk P.N., Uvarovsky A.P. Methodological concept of education management as an integrated model of science and practice // Actual problems of humanities and natural sciences. - Moscow, 2015. № 11(6). - P. 86-94.
18. Gorelova G.V., Radchenko S.A. Software system of cognitive modelling of socio-technical systems // Izvestia YuFU. Technical Sciences. - Taganrog, 2004. №4. - P. 218-227.
19. Astafurova I.S., Antonenkova S.Y. Evaluation of methods of forming a system of indicators of organisations' activity // Economics and Entrepreneurship. - Moscow, 2014. - № 12-3 (53). - P. 850-854.
20. Methodological Recommendations on the Analysis of Financial and Economic Activities of Organisations: Approved. 28 November 2002. http://docs.cntd.ru 12.04.2019.
21. Ionova A.F., Selezneva N.N. Financial Analysis. - Moscow: Prospect, 2006. -623 p.
22. Pismarov A.F. How to assess the efficiency of work // General Director. – 2006. № 2. - P. 26-33.
23. A. Gershun. Balanced scorecard for holding-type enterprises., https://www.mag-consulting.ru/asp/maps 12.04.2019.
24. Hladchenko M. Balanced Scorecard - a strategic management system of the higher education institution // International Journal of Educational Management. - 2015. - Vol. 29, - No. 2. - P. 167-176. DOI: 10.1108/IJEM-11-2013-0164
25. Golovko N.V., Zinevich O.V., Ruzankina E.A. University's third mission and stakeholder governance

for regional development. V., Ruzankina E.A. University's third mission and stakeholder governance for regional development // Sravnitelnaya Politika-Comparative Politics. - 2018. - Vol.9, - No. 1, - P. 5-17.
26. Ponomarenko T., Tohochynskyi O., Kaminska T., Kadol L., Okhrimenko I. Strategic planning in universities: A case of Ukraine // Problems and Perspectives in Management. - 2018. - Vol. 16. - № 4. - P. 365-374. DOI: 10.21511/ppm.16(4).2018.30
27. Mazelis L., Lavrenyuk K. Devising a fuzzy model for compiling a plan of activities aimed at developing human capital in university // Eastern-European Journal of Enterprise Technologies. - 2017. - Vol. 4. - № 3-88. - P. 35-44. DOI: 10.15587/1729-4061.2017.108753
28. Edmunds L.D., Gluderer S., Ovseiko P.V., Kamerling R., Ton J., Vis L., Jenni M., Tutton G., Lawton-Smith H., Nadabán M.V., Rab M., Rees J., Anson J., Rushforth A.D., Allen M., Buchan A.M., Vendrell M., Casta A., Mehes G., Hogendoorn P.C.W., Hafen E., Hassan A.B. New indicators and indexes for benchmarking university-industry-government innovation in medical and life science clusters: Results from the European FP7 Regions of Knowledge HealthTIES project // Health Research Policy and Systems. - 2019. - Vol. 17. - № 1. - P. 10. DOI: 10.1186/s12961-018-0406-9
29. Al-Zoubi M.T. Generating benchmarking indicators for employee job satisfaction // Total Quality Management and Business Excellence. - 2012. - Vol. 23. - № 1. - P. 27-44. DOI: 10.1080/14783363.2011.637794
30. Alonso K.R., Morales G.B.C., Lopez C.G. Indicators for the strategic control at cienfuegos university // Revista Universidad Y Sociedad. J.G. Indicators for the strategic control at cienfuegos university // Revista Universidad Y Sociedad. - 2015. - Vol.7. - No. 3. - P. 56-62.
31. Saule K., Indira U., Aleksander B., Gulnaz Z., Zhanl M., Madina I., Györök G. Development of the information and analytical system in the control of management of university scientific and educational activities // Acta Polytechnica Hungarica. - 2018. - Vol. 15. - № 4. - P. 27-44. DOI: 10.12700/APH.15.4.2018.4.2
32. Prangishvili, I.V. Entropic and other system regularities: Issues of complex systems management. / I.V. Prangishvili; Institute of Control Problems named after V.A. Trapeznikov. V.A. Trapeznikov. - Moscow: Nauka, 2003. - 428 p.
33. Gunay O., Toreyin B.U., Kose K., Cetin A.E. Entropy-Functional-Based Online Adaptive Decision Fusion Framework With Application to Wildfire Detection in Video // IEEE Transactions On Image Processing. – 2012. - Vol.21. - P. 2853-2865. DOI: 10.1109/TIP.2012.2199325
34. Cheng S.H. Autocratic multiattribute group decision making for hotel location selection based on interval-valued intuitionistic fuzzy sets // Information Sciences - 2018. - Vol. 427. - P. 77-87. DOI: 10.1016/j.ins.2017.10.001
35. Liu P.D., Tang G.L. Some Intuitionistic Fuzzy Prioritised Interactive Einstein Choquet Operators and Their Application in Decision Making // IEEE ACCESS. -2018. - Vol. 6. - P. 72357-72371. DOI: 10.1109/ACCESS.2018.2882702
36. Liu P.D., Qin X.Y. An Extended VIKOR Method for Decision Making Problem with Interval-Valued Linguistic Intuitionistic Fuzzy Numbers Based on Entropy // Informatica. - 2017. - Vol. 28. - P. 665-685. DOI: 10.15388/Informatica.2018.174
37. Ye J. Cross-Entropy of Dual Hesitant Fuzzy Sets for Multiple Attribute Decision-Making // International Journal Of Decision Support System Technology. 2016. - Vol. 8. - P. 20-30. DOI: 10.4018/IJDSST.2016010102
38. Huan J., Bo R. Application of the Big Data Grey Relational Decision Making Algorithm to the Evaluation of Resource Utilisation in Higher Education // International Journal Of Enterprise Information Systems. - 2018. - Vol. 14. - P. 43-55. DOI: 10.4018/IJEIS.2018070104
39. Toptsis A.A. Toward a better syllabus: Entropy-driven introspection for alternative lesson plans // Journal of Computing and Information Technology. - 2009. - Vol. 17. - P. 335-346. DOI: 10.2498/cit.1001504
40. Hein N., Kroenke A., Júnior M.M.R. Professor assessment using multicriteria decision analysis // Procedia Computer Science. - 2015. - Vol. 55. - P. 539-548. DOI: 10.1016/j.procs.2015.07.077
41. Wang Y., Li H., Ding Z. Information Literacy Assessment with a Modified Hybrid Differential Evolution with Model-Based Reinitialisation // Computational Intelligence and Neuroscience. - 2018. - Vol. 22. DOI: 10.1155/2018/9183676
42. Aspects of the use of information approach for company management // Proc. of the international symposium "Sovnet-99", - M., 1999.

43. Kulikov V., Iklassova K., Kazanbayeva A. Entropy based decision making method in managing the development of a socioinformational system // Journal of theoretical and applied information technology. - 2020. - Vol. 98. № 01. - P. 92-102. DOI: 10.5281/zenodo.3870618

Information about the author:

Iklassova K.E. – corresponding author, PhD, Associate Professor, Department of Information and Communication Technologies, Faculty of Engineering and Digital Technology, Manash Kozybayev North Kazakhstan University NPLC, Petrolpavlovsk, Kazakhstan; e-mail keiklasova@ku.edu.kz.