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Проектирование экосистемы развития университетов в цифровой среде

Цифровизация экономических отношений обуславливает особую важность подготовки кадров на качественно новой технологической основе, что неразрывно связано с исследованием проблемы проектирования экосистемы развития университетов в цифровой среде. В ходе изучения проблемы развития экосистемы университетов использовались фундаментальные основы теории систем, теории экономики образования, методы системного анализа, факторного анализа и экономико-математического моделирования.

Проведенные исследования позволили получить такие основные результаты исследования, как: предложены экосистемные принципы организации предоставления услуг высшего образования, отражающие целостность системы университета на основе сетевых взаимодействий совокупности различных участников, а также объектов, проектов, процессов и сред. На основе сценарного прогнозирования восприимчивости компетенций цифровой экономики студентами, преподавателями и партнерами университетов на среднесрочную перспективу предложен подход к проектированию стратегии развития университетов на основе органограммы реализации проекта матричной цифровой трансформации адхократичной иерархии университета.

Сформулированы выводы, что проектирование экосистемы развития университетов должно быть направлено на реализацию социальной миссии университета в регионе и преобразование экосистемы региона в целом. В качестве перспектив дальнейших исследований рассматривается исследование предпосылок генерирования эффектов проектирования экосистемы развития университета на основе сетевого платформенного взаимодействия экономических агентов региона / территории, а также внедрение проектов цифровой трансформации системы управления университета.

Ключевые слова: система, экосистема, цифровая экономика, высшее образование, университет, сетевое взаимодействие, эффекты

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Ecosystem designing for the development of universities in a digital environment

The digitalization of economic relations determines the particular importance of personnel training on a qualitatively new technological basis, which is inextricably linked with the study of the problem of ecosystem designing for the development of universities in a digital environment. The foundations of the systems theory, the theory of education economics, the methods of system analysis, factor analysis, and economic and mathematical modeling were used for studying the problem of ecosystem development for universities.

The conducted studies made it possible to obtain the following main research results: the ecosystem principles for organizing the provision of higher education services, representing the integrity of the university system based on network interactions of a set of various participants, as well as objects, projects, processes, and environments, were proposed. An approach to designing a strategy for the development of universities, based on the scenario forecasting of the receptivity of digital economy competencies by students, teachers, and partners of universities in the medium term, is proposed based on the organigram for the implementation of the project of matrix digital transformation of the adhocratic university hierarchy.

The conclusions stating that the design of the ecosystem of the development of universities should be aimed at the implementation of the social mission of the university in the region and the transformation of the ecosystem of the region as a whole are formulated. As prospects for further research, the study of the prerequisites for generating the effects of designing the development of a university ecosystem based on the network platform interaction of the economic agents of the region/territory, as well as the implementation of digital transformation projects of the university management system, is considered.

Keywords: system, ecosystem, digital economy, higher education, university, networking, effects

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Introduction

The formation of a new quality of technological development in Russia determines the importance of digitalization in the field of higher education, which actualizes the particular importance of improvement of the university management system in the digital environment. The strategic objectives to train annually up to 120 thousand graduates of higher education institutions in the field of information and telecommunication technologies, as well as 800 thousand graduates of higher and secondary vocational education with competencies in the field of information technology at the average world level; to provide 40% of the population with digital skills, were approved by the National Program "Digital Economy of the Russian Federation"*. These objectives determine the requirements for the development of the market for higher education services, which is directly related to the transformation of the strategic role of universities in assisting citizens in the development of digital literacy and competencies of the digital economy.

The implementation of the digital agenda for the development of the national economy is accompanied by unprecedented risks of the impact of the spread of the new coronavirus infection (2019-nCov) on the structure of economic relations in society. Against the background of changes in the quality of life of citizens in the new economic conditions, the structure of the market for higher education services is also changing in terms of the growing demand for online education [14], the readiness of market participants to intensify the interaction [22].

In the context of the accelerated digitalization of higher education, digital transformations in higher education [15], the effective implementation of new forms of online education [18], and the integration of digital competencies of university graduates into the system of relations between economic agents of the digital economy [21] are of particular importance. In this regard, the development of the market for higher education services is inextricably linked with the design of the ecosystem for the development of universities in the digital environment [23], within which various forms of competition and cooperation arise [28] both between educational service providers and between service consumers [12].

This study is concerned with the development of a scientific and methodological approach to designing an ecosystem for the development of universities in a digital environment. The use of this toolkit will make it possible to make management decisions in the field of strategic development of universities based on network design of interaction, which would ensure a balanced development of the region's ecosystem and the economic growth of territories.

Materials and methods

The mainstay of the systems theory was used in the course of studying the problem of designing an ecosystem for the development of universities in a digital environment. The development of the conceptual provisions of the systems theory in the digital economy actualizes the special attention of researchers to the application of the essential laws of the systems approach to explaining a number of contradictions of digitalization and its impact on

* The design passport of the "Digital Economy of the Russian Federation" National Program. Approved by the decision of the Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects on December 24, 2018. Retrieved August 22, 2020, from <http://government.ru/rugovclassifier/614/events>

economic development and the welfare of society. Moreover, in the course of the research, an integrative approach was repeatedly applied to the interdisciplinarity of the collection of materials, analysis, and assessment, as well as the provisions of the theory of education economics, methods of system analysis, factor analysis, and economic and mathematical modeling.

Results

The systems theory and the university ecosystem

The approach to environment analysis from the standpoint of general systems theory was first applied by Bertalanffy back in the 1940s. "Systems are everywhere. We cannot always formalize our understanding of systems, but we definitely feel their impact" [17]. General systems theory is based on the achievements of various sciences, such as biology, sociology, and economics, substantiating the interdisciplinary principles of application and interconnection in their further interaction and interpenetration [24]. The systems approach, based on "understanding the holistic, general properties of large, complex systems as a whole, in particular, on the relationships that, being in development, arise when systems interact in the process of their functioning, was transformed in the twentieth century into a subject, without which it is impossible to imagine modern theory and practice of purposeful human activity" [6].

Considerable attention in modern publications is paid to the study of ecosystems and their development. The formation of this field of economic science is largely associated with digitalization and the development of the platform economy. A number of scientists interpret the ecosystem in two aspects: as a set of coordinated functional interactions, based on belonging to certain properties, and as a structure of various partners whose actions are aimed at the materialization of common values [13, p. 41]. The functional aspect of the ecosystem is directly related to the openness of the system, the absence of clearly defined boundaries, the development of networking between partners based on platforms [30]. The Microsoft ecosystem, the Silicon Valley ecosystem, the entrepreneurship ecosystem, etc. can serve as examples of such ecosystems in the business environment [13]. As for the ecosystem as a structure, an important element here is the structured relationship between economic agents in order to generate income based on shared values.

Kleiner introduces the concept of a socio-economic ecosystem as a set of localized complexes of organizations, business processes, innovative projects, and infrastructure systems capable of long-term functioning in a stable socio-economic environment due to the circulation of resources, products, and abilities [3]. According to Karpinskaya, an ecosystem, as a unit of economic analysis, is a network of cooperating and competing firms that offer related products and services [2].

The studies show that the ecosystem implies the connection of the organization with the actors that influence its activities or are influenced by it, in particular, on the basis of platform management [7]. In the works devoted to the study of ecosystems of organizations in the business environment, it is indicated that ecosystems are characterized by the absence of clearly expressed traditional hierarchies and have network structures [31, 33]. The following directions of ecosystem formation can be distinguished: 1) an ecosystem based on an individual firm (business ecosystem) [7]; 2) an ecosystem based on a specific innovation [26]; 3) the ecosystem based on a platform [21].

Taking into account these approaches to the formation of ecosystems, the designing of an ecosystem for the development of universities can hardly be deliberately set according to any one specific vector. Rather, it is about choosing one of the directions in order to implement the social mission of the university in the region. It is very important to substantiate the boundaries of the university ecosystem, including from the standpoint of general systems theory and institutional theory. “The university can be considered as one of the most striking examples of a polystructural ecosystem, including clusters, platforms, networks, incubators. The concept of interdisciplinary systemic management of the university is aimed at developing the systemic (ecosystem) properties of the university, ensuring its integrity in space and continuity in time” [4]. It is the systemic properties of the university, according to the general theory of systems, that determine the systemic principles and functional relationships of the university with the economic agents of the environment, which, in turn, determine the boundaries of the ecosystem.

Ecosystem principles for the development of universities

With the development of the platform for the socio-economic development of universities, the ecosystem principles of the development of universities in the digital environment are understood to mean the main provisions and norms of behavior that guide the management bodies when making management decisions based on the use of end-to-end digital technologies, information resources, services, networks, and infrastructure that provide the intrasystem unity and integrity of the subsystems of the university ecosystem, the compliance of educational and research activities, as well as management processes of the university, with the social mission of the university in the region of presence. Defining the mission of third-generation universities, Wissema emphasized that the commercialization of know-how was a third goal in addition to the goals of development of research and education. “In the era of second-generation universities, it was enough for the universities to be engaged in scientific research and to implement the educational programs based on them. Today, universities are seen as incubators of new businesses related to science and advanced technology. Therefore, there is a growing demand for universities to benefit from the new knowledge they create” [1].

For the purposes of the development of the ideas of Wissema, widely cited in scientific circles in relation to the formulation by universities of their third goal, the authors consider it necessary to complement the development of the social mission of the university, reflecting the importance of the university in the region of presence. In turn, the formation of the university ecosystem should transform the ecosystem of the region.

The following ecosystem principles for the organization of the provision of higher education services can be identified:

- the principle of the platform organization of the provision of higher education services in the context of digitalization based on the network interaction of educational organizations;
- the principle of network organization of the digital infrastructure of management, educational process, research and development in an inextricable relationship and interaction with partners and other economic agents;
- the principle of differentiation of higher education services using end-to-end digital technologies;
- the principle of permanent implementation of breakthrough digital technologies in the development of online education based on the introduction of domestic

- products, services, and platform solutions;
- the principle of continuous training of the teaching staff of universities, students, and other interested parties in the competencies of the digital economy;
- the principle of personnel motivation to master the competencies of the digital economy;
- the principle of constant updating of the basic competencies of the digital economy with the subsequent coordination of basic and professional competencies in the areas of training;
- the principle of transformation of teaching methods in ensuring the formation of personal development trajectories for the implementation of digital competencies of students in the labor market;
- the principle of systematic monitoring of the assessment of the provision of educational services for higher education in online programs using information and communication technologies.

The above ecosystem principles represent the defining systemic property of the university – the integrity of the system based on network interactions of not only a set of various participants but also objects, projects, processes, and environments [4].

The development of the market for higher education services is undoubtedly associated with various kinds of network effects. The generation of network effects is directly determined by the possibility of receiving a benefit for all network participants. Thus, each subsequent network participant can increase the usefulness of the network for other network participants. When studying the network effect, it becomes clear that the increase in the network effect occurs when a critical number of users of a product or service, or the so-called “critical mass”, is reached. According to Nureev, “the principle of increasing utility operating in the network leads to a paradoxical phenomenon, from the point of view of traditional microeconomics, when the network becomes ‘more interesting’ for its participants with an increase in the number of people” [9]. This dependence, known as Metcalfe's law, shows that the utility of a network is proportional to the square of the number of its users [32]. The use of Metcalfe's law in relation to the educational services market makes it possible to note the increasing usefulness from the use of this technology, as a result of which the educational service becomes “smarter” in the process of use.

The manifestation of network effects is closely related to the formation of network goods. The following properties are characteristic of network goods: the property of complementarity; the property of significant economies of scale of production; the property of network externalities; the property of trap effects [9]. Let us consider each of these properties. Complementarity as a property of a network good means that this or that good is used in conjunction with other benefits of this network. It should be noted that consumers purchase not a separate good, but elements of a single network, of which they are members. In this regard, during the formation of a network, a significant share of costs falls on the initial stage of the production of network goods. At the same time, the production costs of the first instance of the good are very high. It should be emphasized that this is the main contradiction of the neoclassical theory with the foundations of the development of the digital economy.

If, according to neoclassical economic theory, with the long-term use of goods, the law of diminishing utility operates, then in the digital economy, the long-term use of network goods leads to an increase in utility and an increase in profitability. With regard to economies of scale in the study of network effects, then, taking into account the fact that in the network

the good increases its value exponentially, in the network even small and medium-sized enterprises have the opportunity to receive certain benefits by creating many different economic units. Despite the criticism of Metcalfe's law from a number of scientists in terms of inaccuracy in predicting the growth of the utility of the network [19], this law remains an important tool for setting goals in the process of developing innovations in the digital educational environment.

Digital transformation of higher education

Digitalization directly affects the rapid development of platform competition. The development of the market for higher education services is inextricably linked with the active introduction of artificial intelligence technologies, which in a new way determine the development of forms of competition and cooperation between economic agents in the educational services market. Nowadays, the superiority of natural intelligence over artificial intelligence is expressed in the ability of natural intelligence for critical and creative thinking, as well as in the presence of so-called “emotional intelligence”. The generalized name for such skills is defined by researchers as “the competencies of the 21st century” (digital competencies). The following groups of digital competencies are known: value choice competencies; the competence for planning and organizing activities; the competence to carry out activities; the competence of self-government and self-development of the subject in the activity; performance management competencies; the competence in assessing and accounting for the consequences and effects of activities. All these competencies determine the superiority of natural intelligence over artificial intelligence according to the principle of planning one's activities and assessing the results of activities within the framework of the decision.

The development of the digital economy shows that the latest disruptive technologies such as artificial intelligence, the Internet of Things, digital platforms, quantum computing, digital twins, and blockchain are significantly changing the traditional models of providing higher education services. The analysis of trends in the development of the higher education services market in Russia for the period of 2014–2019 shows an increase in the volume of the online education market, along with the decrease in the volume of the market for classic forms of offline education (Table 1).

Table 1

Dynamics of changes in the development indicators of the market for higher education services for 2014–2019

Item	Indicator	Year					
		2014	2015	2016	2017	2018	2019
1	Higher education market volume, RUB bln	388	385	386	378	370	361
2	Number of students (% of the total number of current year graduates who chose higher education instead of secondary vocational education)	61	63	60	55	53	52.5
3	Private higher education market volume, RUB bln	37	35	34	31	30	28
4	Financing dynamics, RUB bln	359	358	352	334	325	318
5	Number of students, thousand people	7052.3	7050.1	7048.8	4399.5	4245.9	4161.7
6	Online education market volume, RUB billion	5.4	6.0	6.8	8.4	10	11.6

Source: compiled by the authors on the basis of Rosstat data, information and analytical materials of the main information and computing center of the Ministry of Science and Higher Education of the Russian Federation.

The spread of coronavirus infection has caused an accelerated transition of educational organizations to online education, which also determines in the future the demand for specialists capable of ensuring the functioning of the online services market. In this case, the development of digital skills among university teaching staff, which, along with “hard skills” and “soft skills,” form a stable emotional intelligence of a modern specialist in the labor market in the context of digital transformations, is of particular importance.

Since online education is often characterized not only by synchronous frontal forms of implementation of educational programs but also by asynchronous forms of implementation of programs, special requirements are imposed on mastering deep digital competencies of the teaching staff in the implementation of distance educational forms, since the correct implementation of e-learning using distance educational technologies not only increases the effectiveness of the transfer of knowledge to students but also to a greater extent disposes students to obtain knowledge from a particular teacher. Thus, in the context of digital transformation, the teachers’ digital skills become more of their flexible soft skills, since in the digital era, not only educational technologies but also communication methods are also undergoing digital transformation.

The conducted studies of the dynamics of digitalization in the sphere of higher education made it possible to identify the determinants of digital transformations of the market for higher education services: digital transformation of management relations “ecosystem – university management system”; competition of digital platforms in the market for higher education services; permanent technological changes; differentiation of online education services in the areas of training students; continuous training of personnel in the digital economy competencies.

It should be noted that digital transformations of management relations “ecosystem – university management system” occur under the influence of digital technologies. Let us focus on three types of management relations “ecosystem – management system”: relations of an intersystem nature; relations of intra-organizational regulation; platform management relationship. The determinants of digital transformations in the market for higher education services that have been indicated, indicating an inevitable increase in the volume of online services in the future, do not aim to oust traditional forms of providing educational services from the market, but characterize the strategic directions of ensuring the competitiveness of higher education organizations in the context of digitalization.

The list of competencies in the digital economy represents a unified system of basic and professional competencies in digital economic activity, which establishes uniform requirements for the processes and results of education, as well as for qualifications in the Russian Federation. The formation of students' competencies is directly related to the restructuring of the content of the educational process. In this direction, it is necessary to note the active use of information technologies, as well as practice-oriented technologies.

With the development of the computing power of digital systems, cloud technologies, and other tools for working with large amounts of data (big data), a trend inevitably arises to optimize the processes of analyzing such data. Such optimization, one way or another, is adjacent to the delegation of a part of the analytical work to advanced computing systems. Today, systems such as neural networks are increasingly being used in processes in which “digital technology” has not been used previously. However, such penetration of “digital technology” is associated with a certain conflict. A neural network or artificial neural network (ANN) is, in its essence, one of the most successful attempts to imitate the human mind. Such a network is a certain mathematical model built on the principle of the organization

and functioning of biological neural networks (the nervous system as a network of nerve cells in a living organism), as well as a software (and often hardware) embodiment of such a mathematical model. In the same way as it happens in biological neural networks, an ANN is a system of interaction of interconnected simple processes (the so-called “artificial neurons”). Moreover, despite the simplicity of such processes (each process interacts only with signals that it can either receive from other processes or send to other processes), the system of such artificial neurons is capable of performing rather complex tasks. A particularly relevant application of such neural networks is (due to their ability to self-learn based on prescribed algorithms and provided data for analysis) the automation of monotonous repetitive processes or the automation of forecasting processes. Moreover, in a situation of the digital transformation of economic processes, which are often based on complex and multifactorial causes of their occurrence, the prognostic function of such neural networks becomes more relevant than ever. The practical application of artificial intelligence makes it possible to automate various processes, thereby accelerating the development of the area of knowledge in which such neurosystems are used.

However, the rapid introduction of artificial intelligence technologies in higher education raises a number of concerns among such Russian scientists as Kodaneva [5], Maksimov and Klyshinskii [8], Proidakov [10], Razin [11]. This refers to the work with analytical information arising through the functioning of neural networks. Obviously, any analytical information has no applicable function until the operator determines what actions need to be taken based on the information received. As an example, one can note the work of unmanned vehicles, which not only analyze the information received but also make decisions on the procedure for action in a certain traffic situation; in particular, an ANN can recognize a collision with a pedestrian as a collision with a road sign.

With the increasing involvement of a person in the development of artificial intelligence and decision-making based on ANN data, the profession is undergoing serious changes in the labor market. Of course, each industry will require its own special digital competencies, the most important of which may be:

- systematic and consistent research in the field of automation architecture and the creation of process algorithms (automation scenarios);
- big data analytics, including fast search and processing of online big data, the ability to identify future trends based on the extracted insights;
- the ability to interact with the interfaces of software robots and digital platforms in their industry; development of user skills for working with applied artificial intelligence systems.

In this regard, the training of specialists by universities should be carried out using predictive technologies aimed at both training personnel for the digital economy and developing the ecosystem of the region of presence.

In order to study the prerequisites for designing an ecosystem for the development of universities in the digital environment, the authors analyzed the impact of digital technologies on the level of demand for higher education services using the example of universities in the Chelyabinsk Region (28 universities are state-owned, including branches of educational institutions of higher education, 4 universities are private). An analysis of indicative indicators of the activities of universities in the Chelyabinsk Region and the Ural Federal District based on the methodology for monitoring the effectiveness of educational organizations indicates an increase in the volume of services and the number of students in higher education institutions, including foreign students studying on a paid

basis. The data confirm the positive dynamics of research activities and the trend towards an increase in the number of institutions with the status of recipients of grants and subsidies. However, despite the fact that the Chelyabinsk Region, in comparison with the general trend of change in the indicator “Educational activity” of the Ural Federal District, shows more stable results, the region does not fully realize the potential of providing educational services in the market of educational services of higher education and, in aggregate with a high potential for scientific research, has significant reserves in terms of training domestic digital economy specialists.

During the assessment of the factors affecting the demand for the implementation of educational programs of higher education on the formation of the digital economy competencies with the involvement of 170 students, 183 teachers, and 52 employers, it was revealed that students are aware of the need to develop the digital economy competencies during the period of study in higher education programs for higher education to receive the competitive advantage in the labor market after obtaining the relevant specialty.

With the help of the multifactorial analysis carried out, which was based on data on the influence of certain factors on demand in the implementation of the educational program for the formation of digital economy competencies, it was found that students realized the need to develop digital economy competencies during the period of study in higher education programs for a higher competitive advantage in the labor market after obtaining the relevant specialty. The table below shows the values of those factors, the load of answers to which takes the maximum values. Students' requests for the formation of digital competencies coincide with the requests of employers regarding the requirements for applicants when hiring.

It should be noted that the positions of students regarding the formation of digital competencies coincide with the requests of employers regarding the requirements for the applicants. At the same time, direct providers of educational services through which educational programs of higher education are implemented (teachers of higher educational institutions) are not fully focused on meeting such demand among students, since they do not have information about the factors that form such a demand.

In determining the prospects for the development of the market for higher education services, scenario forecasting was used, which makes it possible to take into account not only the impact of the main factors and conditions of the forecast environment but also the impact of managerial decisions aimed at minimizing the impact of possible crisis situations and increasing the effectiveness of the implementation of the selected economic scenario. The scenario forecast was made for the period up to 2024 (until the end of the period of implementation of the national projects “Education” and “Science”, as well as the national program “Digital Economy of the Russian Federation”). To design scenario forecasts, Brown's predictive adaptive model toolkit was selected for the process of exponential smoothing of the series. The author's contribution to the practice of using Brown's method for building predictive models is that this method has not previously been used to predict the state of the market for higher education services in the medium term. As part of the implementation of national projects and programs, in particular, the National Projects “Education” and “Science”, as well as the National Program “Digital Economy of the Russian Federation”, especially as part of the implementation of indicators of such programs and projects, for the service market as a whole and for individual educational organizations, in particular, it is necessary to design their development programs taking into account the forecast of the state of the market.

Taking into account the goal of the scenario forecast, the market share of online education by 2024 has been determined at the level of 17.1%, which seems quite real if the current state of the education system in the Chelyabinsk Region remains in line with the current digitalization trends. Thus, in absolute terms, the value of online education in the total volume of the market for higher education services should be 2,131.16 million rubles. For the online education market of the Chelyabinsk Region, a combination of two strategies (assortment and competitive) may be effective, since the target audience of the online education market is mainly correspondence students and students of additional professional education programs, and the functional feature of the product is the remote form of providing educational services. The universities using digital educational technologies will get opportunities to improve their image, attract students, improve the quality of education, and determine the focus in conducting digital transformation. The task of developing and implementing innovative educational programs for the online training of the specialists capable of working in new conditions is considered urgent. The measures of management, analytical, and organizational nature necessary for this have been determined, which can be implemented by educational institutions of higher education, depending on the specifics of their financial and economic activities.

Within the framework of scenario forecasting, it is proposed to use jointly the RACI (responsible, accountable, consulted, informed) organigram (the matrix of the sequence of processes of interaction and distribution of work) with the educational platform “Mobile Electronic Education” with maximum variability, which ensures the differentiation of potential users and the personalization of their educational trajectories, taking into account educational requests and projected design organigrammes (Table 2).

Table 2

RACI organigram for the implementation of a matrix digital transformation project within the adhocratic university hierarchy *

RACI organigram	Operation (within competencies) by services					
Structural unit	Analysis of demand and supply formation	PR promotion	Determination of the volume of demand for services	Preparation of content for the implementation of educational programs	Service offer	Service implementation
University administration	C	I	I/C (within the plan for the year)	I	I	I
Educational-methodical unit	A	A	A	A	A	C
Departments	C	C	C	R	C	A
Institute (department) of distance education	R	R	R	A	R	A

* Designation of the role of the structural unit in the educational project:
R – Responsible, A – Accountable, C – Consulted, I – Informed.

Discussion

Designing of an ecosystem for the development of universities in a digital environment is based both on the proposed author's scientific and methodological approach to the formation and development of the university ecosystem and on the existing scientific groundwork of prominent scientists. It should be noted that the obtained scientific results develop the provisions of Bertalanffy's theory of systems in terms of the application of an integrative approach to the study of ecosystems. Along with this, the design of university ecosystems based on the proposed principles does not contradict the conceptual approach of Kleiner in terms of the structure of the socio-economic ecosystem, but, on the contrary, predetermines the theoretical and conceptual prospects for the sustainable functioning of ecosystems in the digital environment.

Moreover, the implementation of new programs of higher education, including additional professional education, in a distance form will complementarily form socio-economic effects. Social effects are manifested in the availability of education without dependence on the regional affiliation of students, an increase in the number of trained specialists, release from the classroom load of scientific and pedagogical workers, the focus of activities on creativity and new projects. Economic effects are achieved directly through income from expanding the target audience of students, as well as indirectly through the use of vacated lecture halls, implementation of scientific grants and projects that will replenish the financial support of an educational institution of higher education with income-generating activities.

Conclusion

The development of universities in the modern digital environment predetermines the search for preventive approaches to the management of educational organizations in the face of heightened competition between platforms and an unprecedented modification of network services. The development of the market for higher education services is inextricably linked with the active introduction of artificial intelligence technologies, which in a new way determine the development of forms of competition and cooperation between economic agents in the educational services market. With the development of platform-based socio-economic development of universities, the design of the ecosystem for the development of universities should be aimed at the implementation of the social mission of the university in the region and transforming the ecosystem of the region as a whole.

The ecosystem principles for organizing the provision of higher education services are proposed, reflecting the integrity of the university system based on network interactions of a set of various participants, as well as objects, projects, processes, and environments. The ecosystem principles for the development of universities in the digital environment are defined as the main provisions and norms of behavior that guide management bodies when making management decisions based on the use of end-to-end digital technologies, information resources, services, networks, and infrastructure that ensure the intra-system unity and integrity of the university ecosystem subsystems, compliance with educational and research activities, as well as management processes of the university, the social mission of the university in the region of presence.

The conducted studies of the dynamics of digitalization in the sphere of higher education made it possible to identify the determinants of digital transformations of the market for higher education services: digital transformation of management relations “ecosystem – university management system”; competition of digital platforms in the market for higher education services; permanent technological changes; differentiation of online education services in the areas of training students; continuous training of personnel in the competencies of the digital economy.

Based on the scenario forecasting of the receptivity of digital economy competencies by students, teachers, and partners of universities in the medium term, an approach to designing a strategy for the development of universities is proposed based on the organigram for the implementation of the project of matrix digital transformation of the adhocratic university hierarchy. The generation of the design effects of the university development ecosystem is provided on the basis of a network platform interaction of economic agents of a region/territory, as well as the implementation of matrix digital transformation projects in the management structure of an educational organization. Social effects are manifested in the availability of education without dependence on the regional affiliation of students, an increase in the number of trained specialists, release from the classroom load of scientific and pedagogical workers, the focus of activities on creativity and new projects. Economic effects are achieved directly through income from expanding the target audience of students, as well as indirectly through the use of vacated lecture halls, implementation of scientific grants and projects that will replenish the financial support of an educational institution of higher education with income-generating activities.

REFERENCES

1. Wissema, J.G. (2016). *Third Generation University: University Management in Transition*. Moscow: Olympus – Business (Sberbank Library. V. 70) (in Russian).
2. Karpinskaya, V.A. (2018). Ecosystem as a Unit of Economic Analysis. In *Systemic Problems of Domestic Meso-economics, Microeconomics, Enterprise Economics: Materials of the Second Conference of the Department of Modeling of Production Facilities and Complexes of the CEMI RAS* (Issue 2, pp. 125–141). Moscow: CEMI RAS (in Russian).
3. Kleiner, G.B. (2018). Socio-Economic Ecosystems in the Light of the System Paradigm. In *System Analysis in Economics – 2018: Proceedings of the V International Scientific and Practical Conference – Biennale (November 21–23, 2018)* (pp. 5–14). Moscow: Prometey (in Russian).
4. Kleiner, G.B. (2019). University as an Ecosystem: Institutes of Interdisciplinary Management. *Journal of Institutional Studies*, 11(3), 054–063 (in Russian).
5. Kodaneva, S.I. (2019). Developments in the Field of Artificial Intelligence as the Basis for the Transformation of Management Mechanisms: Expectations and Risks. *Russia: Trends and Development Prospects*, 14–2, 540–541 (in Russian).
6. Louson, G. (2013). *Journey through the System Landscape*. Moscow: DMK Press (in Russian).
7. Mazhitova, S.K., Dzhazykbaeva, B.K., Denisov, I.V., Polozhishnikova, M.A., & Petrenko, E.S. (2020). Business Management: “Ecosystem” as a New Representation of Economic Relations. *Journal of Economics, Entrepreneurship and Law*, 10(3), 601–614 (in Russian).
8. Maksimov, V.Yu., Klyshinskii, V.Yu., & Antonov, N.V. (2016). The Problem of Understanding in Artificial Intelligence Systems. *New Information Technologies in Automated Systems*, 19, 43–60 (in Russian).
9. Nureev, R.M. (2018). The Digital Economy: On the Cusp of the Fourth Industrial Revolution? *Theoretical Economics*, 6(48), 70–73 (in Russian).
10. Proidakov, E.M. (2018). The State of the Art in Artificial Intelligence. *Science of Science Studies*, 2, 129–153 (in Russian).

11. Razin, A.V. (2019). The Ethics of Artificial Intelligence. *Philosophy and Society*, 1(90), 57–73 (in Russian).
12. Abdul-Jabbar, M., & Kurshan, B. (2015). *Educational Ecosystems: A Trend in Urban Educational Innovation*. Retrieved November 26, 2020, from <https://www.urbanedjournal.org/archive/volume-12-issue-1-spring-2015/educational-ecosystems-trend-urban-educational-innovation>
13. Adner, R. (2016). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, 43(1), 39–58. Retrieved November 26, 2020, from <http://www.sagepub.com/journal.aspx?pid=10604>
14. Alberola, J.M., Del Val Noguera, E., Sanchez-Anguix, V., Palomares, A., & Teruel, D. (2016). An Artificial Intelligence Tool for Heterogeneous Team Formation in the Classroom. *Knowledge-Based Systems*, 101, 1–14.
15. Alonso-Arévalo, J., & Saraiva, R.M. (2020). Information Literacy in the Context of the 21st century University. *Informacion, Cultura y Sociedad*, 42, 153–162.
16. Benitez, G.B., Ayala, N.F., & Frank, A.G. (2020). Industry 4.0 Innovation Ecosystems: An Evolutionary Perspective on Value Cocreation. *International Journal of Production Economics*, 228, Article 107735.
17. Bertalanffy von, L. (1968). *General System theory: Foundations, Development, Applications* (1st ed.). New York: George Braziller, Inc.
18. Branch, J.W., Burgos, D., Serna, M.D.A., & Ortega, G.P. (2020). Digital Transformation in Higher Education Institutions: Between Myth and Reality. In D. Burgos (Ed.), *Radical Solutions and eLearning* (pp. 41–50). Springer.
19. Briscoe, B. (2006). *Metcalfe's Law Is Wrong*. IEEE Spectrum. Retrieved March 11, 2020, from <http://spectrum.ieee.org/computing/networks/metcalfes-law-is-wrong>
20. Casarosa, V., Ruggier, S., Salvator, E., Simi M., & Turbant, S. (2020). Educational Ecosystems for Information Science: The Case of the University of Pisa. *Education for Information*, 36(2), 119–138.
21. Cennamo, C., Dagnino, G.B., Di Minin, A., & Lanzolla, G. (2020). Managing Digital Transformation: Scope of Transformation and Modalities of Value Co-Generation and Delivery. *California Management Review*, 62(4), 5–16.
22. Costaguta, R. (2015). Algorithms and Machine Learning Techniques in Collaborative Group Formation. In *Mexican International Conference on Artificial Intelligence* (pp. 249–258). Springer. Retrieved November 26, 2020, from https://link.springer.com/chapter/10.1007/978-3-319-27101-9_18
23. García-Vélez, R., Moreno, B.V., Ruiz-Ichazu, A., Rivera, D.M., & Rosero-Perez, E. (2021). Automating the Generation of Study Teams Through Genetic Algorithms Based on Learning Styles in Higher Education. In T. Ahram (Ed.), *Advances in Artificial Intelligence, Software and Systems Engineering* (pp. 270–277). Springer.
24. Hieronymi, A. (2013). Understanding Systems Science: A Visual and Integrative Approach. *Systems Research and Behavioral Science*, 30, 580–595.
25. Igual, J.F.J., Martí, E.M., & Ribera, E.M. (2020). Role of the Social Economy and the University in Order to a Venture Based on Technological Knowledge and Values. *Social y Cooperativa*, 98, 31–57.
26. Jacobides M. G., Cennamo C., Gawer A. (2015) *Platforms, Ecosystems, Architectures: Rethinking the Aggregate?* Working paper. Retrieved November 26, 2020, from <https://onlinelibrary.wiley.com/doi/full/10.1002/smj.2904>
27. Kapoor, R., & Lee, J.M. (2013). Coordinating and Competing in Ecosystems: How Organizational Forms Shape New Technology Investments. *Strategic Management Journal*, 3, 274–296.
28. Kyprianidou, M., Demetriadis, S., Tsiatsos, T., & Pombortsis, A. (2012) Group Formation Based on Learning Styles: Can It Improve Students' Teamwork? *Educational Technology Research and Development*, 60 (1), 83–110.
29. Lazazzara, A., Ricciard, F., & Za, S. (2020). Introduction to Digital Ecosystem. *Lecture Notes in Information Systems and Organization*, 33, 1–7.
30. Lee, I., & Shin, Y. (2018). Fintech: Ecosystem, Business Models, Investment Decisions and Challenges. *Business Horizons*, 61, 35–46.
31. McIntyre, D.P., & Srinivasan, A. (2017). Networks, Platforms, and Strategy: Emerging Views and Next Steps. *Strategic Management Journal*, 1, 141–160.
32. Metcalfe, B. (1996). There Oughta Be a Law. *The New York Times*, 15 July. Retrieved April 20, 2020, from <https://archive.nytimes.com/www.nytimes.com/library/cyber/week/0715laws.html#metcalfe>
33. Parker, G., Van Alstyne, M.W., & Jiang, X. (2016). *Platform Ecosystems: How Developers Invert the Firm*. Boston University Questrom School of Business Research Paper No. 2861574.
34. Zheng, Y., Li, C., Liu, S., & Lu, W. (2018). An Improved Genetic Approach for Composing Optimal Collaborative Learning Groups. *Knowledge-Based Systems*, 139, 214–225.

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