

# ЕКОНОМІКА ТА УПРАВЛІННЯ

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## EFFICIENCY OF ADAPTATION OF THE NATIONAL ECONOMIC SYSTEMS TO GLOBAL TECHNOLOGICAL TRANSFORMATIONS: THE ROLE OF THE EDUCATION SYSTEM

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## ЕФЕКТИВНІСТЬ АДАПТАЦІЇ НАЦІОНАЛЬНИХ ЕКОНОМІЧНИХ СИСТЕМ ДО ГЛОБАЛЬНИХ ТЕХНОЛОГІЧНИХ ТРАНСФОРМАЦІЙ: РОЛЬ СИСТЕМИ ОСВІТИ

**Purpose.** Substantiation of the conceptual approach in choosing the parameters of education as a social institution at the country level during the cyclical technological transformation of the global economic space.

**Methodology.** System modelling, system analysis and design of actual characteristics of the education system which should be adequate to the condition of the national economy and the requirements of a qualitative technological transformation of the global economy.

**Findings.** The problem of the positioning of the national economy in the global economic space during the period of technological change or the fourth industrial revolution is considered. The role of the education system in transitional periods of economic development as an institution accelerating technological progress is substantiated. Within the theory framework of institutionalism with the use of system analysis, a conceptual approach has been formed. That conceptual approach helps to select the actual characteristics of the education system, taking into account the condition of the national economy. The regulations of the model of the didactic system are interpreted by means of economic terms taking into consideration global technological transformations. The conceptual approach to the choice of the structure of the education system in the “global – national” range is argued and the determinants of this choice are characterized.

**Originality.** The conceptual approach to the implementation of the design of the education system is substantiated, the purpose of which is to increase the efficiency of adaptation of the national economy to global technological transformations.

**Practical value.** The proposed conceptual approach is the basis for developing methodological support for the coordinated development of the economy and education as social institutions. This should include: searching for an education model relevant to a new level of technological development (the sixth technological mode/fourth industrial revolution); revealing the parameters of the model of education, adequate to the role of the country in the world division of labor, taking into account national interests and global integration of the country’s economy into the world economic and educational space.

**Keywords:** *economy, education, institute, technological mode, industrial revolution, globalization*

**Introduction.** The qualitative change in the technological level of the development of civilization, which is currently observed, requires adequate institutional support, which is manifested in the development of institutions that form human and social capital as prerequisites for the development of economic relations stimulating development.

Institutional determinants become important during the transition periods of economic development, especially when it concerns the long-term cyclical dynamics caused by qualitative technological shifts.

The role of institutions in the development of economic systems has been examined in detail by J. Clark, A. Berle, G. Means, J. Galbraith, W. Rostow, D. North. According to D. North, the set of institutions is “a mixture: some institutions promote growth, others lead to a

decline in productivity. Changes of institutions almost always create opportunities for increase, as well as for decrease in economic activity” [1]. The presence of an institutional environment, which facilitates the technological progress in essence and the diffusion of innovations in the economic activities of the subjects, is one of the basic determinants of the positioning of the given economic system (national economy) in the global economic space in the period of the observed technological transformation.

The technological readiness of the business to acquire new ways of production, the ability to develop and implement innovations that form the competitiveness of the modern economic systems are largely determined by the coordinated functioning of the education system. In this perspective, forming the parameters of the education system that support the technological development of the national economy is an urgent task at the present level that is characterized by global technological changes.

**Analysis of the recent research and publications.** The main research trends in technological development are based on theories of cyclic wave dynamics (F. Braudel, I. Wallerstein, Yu. Glaziev, N. Kondratiev, S. Kuznets, V. Maievskii, J. Schumpeter, K. Schwab) and postulate a qualitative transition in the development of the global economy. The transitional stage is defined by scientists as the fourth industrial revolution (or the establishment of industry 4.0) and as the formation of the sixth technological mode.

The concept of industrial revolutions belongs to the Swiss economist K. Schwab.

According to this conception:

- the first industrial revolution used the power of water and steam to mechanize production;
- the second industrial revolution used electricity for conveyor production;
- the third one used automated production with the help of electronics and information technology;
- the fourth industrial revolution is based on the third one, i.e. since the middle of the last century the digital revolution in all spheres of life has continued, technologies have merged, and the boundaries of the material, digital and biological worlds have been blurred [2].

The conception of technological structures, in its turn, was formulated by S. Glaziev and C. Perez. A technological mode is a set of connected manufactures that have a similar technical level and develop synchronously [3].

It is believed that the world has passed five technological modes and at the moment the sixth technological mode is coming, the nucleus of which is: nanoelectronics, nanochemistry, molecular and nanophotonics, nanomaterials and nanostructured coatings, nanosystem technique, nanobiotechnologies, information technologies, cognitive sciences, social and humanitarian technologies, convergence of nano, bio, info and cognitive technologies (the so-called NBIC-convergence) [3].

Chronology of the sixth mode includes:

- 2010 – the beginning of the technological development;
- since 2018 – a period of wide dissemination;
- since 2040 – the end of a phase of rapid growth [3].

Both of these conceptions postulate a global technological revolution, the results of which will determine new leaders and economies that catch them up; and some economic systems will be thrown away from the technological progress for a long time.

Taking into account the impending technological changes, the World Bank formulates and regularly adjusts knowledge and skills that will be the most significant for the development of advanced economic systems for medium and long periods. Thus, a complex of necessary skills for a successful job search in dynamics is presented in the Report of the World Economic Forum “The Future of Work: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution” (January, 2016) (Table 1).

At the same time, there is an increase in the set of options for the development of the education system, models for training, and the organization of the educational process. The modern developed countries are in the process of searching for an adequate educational model, the functioning of which is optimally coordinated with the needs of the national economy during the establishment of the industry 4.0.

Thus, in Finland, the traditional lesson system is gradually disappearing from the senior classes of school education – sixteen-year-olds study not school subjects, but “phenomena” or processes. Thus, the education system reflects the principle of interdisciplinary cognition, inherent in the post-noclassical stage of the development of science, develops the ability to synthesize knowledge in solving complex problems.

In Japan, there is an experimental development in the way of correcting the content of education, which lies in a sharp reduction in the study of social disciplines and the early introduction of the younger generation into the robotic industry. Moreover, according to the decision of the Ministry of Education, Culture, Sport,

*Table 1*  
Necessary skills for a successful career [4]

2015	2020
1. Comprehensive approach to problems	1. Comprehensive approach to problems
2. Coordination of actions with others	2. Critical thinking
3. People management	3. Creativity
4. Critical thinking	4. People management
5. Interaction, negotiation	5. Coordination of actions with others
6. Quality control	6. Emotional intellect
7. Service Orientation	7. Making judgments and making decisions
8. Making judgments and making decisions	8. Service Orientation
9. Active listening	9. Interaction, negotiation
10. Creativity	10. Cognitive flexibility

Science and Technology of Japan, computer programming will become a compulsory subject in the primary school from 2020. In primary school, computer programming will be taught in a game form. Training materials have already been developed, for example, children write programmes for managing game characters, compiling an algorithm from original “building blocks”.

At the same time, the UK Parliament believes that the modern education system should adapt to the changing workforce market and refrain obsolete skills from teaching so as not to form a “useless class”. The focus should be on items that cannot be done well by machine in near future.

The national educational projects as well as global ones are implemented in distance form, the purpose of which is to significantly expand access to contemporary knowledge that will help countries to reduce the level of international inequality.

**Unsolved aspects of the problem.** Despite the changes in the education system at the level of individual states, these attempts are experimental and local. At the same time, one issue has not worked enough. It is the formation of a conceptual approach and methodological support for the reform of education as a social institution that will accelerate the technological development and economic transformations.

In the conditions of formation of a new cycle of technological development, the problem of the consistency of the quality of institutions and the global economic system is actualized. The pace of development of the education system as a social institution can be lagging, modern and advanced. We can also note the level of substantive coherence in the development of the economic system and education as a social institution. In other words, it is advisable to point out two parameters for the coherence of the development of the education system and the national economy: 1) *temporary* (ideally, the education system should outpace economic development, be proactive); 2) *substantive* (the content of education should be coordinated with the national economy). Significant gaps in both the temporary and substantive aspects of coherence in the development of the economy and education negatively affect the economic development of the country. On the contrary, ensuring an optimal degree of coherence can become an impetus (driver) for economic growth in the period of technological transformations.

As an example, let us take a well-known economic plot – the growth of the American economy in the XIX century. At the beginning of the last century, the basic institutional framework was formed in the United States (the Constitution and the Statute of the Northwest Territories, as well as norms of behaviour encouraging hard work), which led to the development of economic and political organizations (Congress, local political bodies, family farms, trading houses, shipbuilding companies). The activities of these organizations, aimed at maximizing the result, led to increased productivity and economic recovery. That impact was both direct and indirect (due to the promotion of investment in education). Through those investments, not only a free system of

public education has appeared, but experimental agricultural stations were set up which have increased productivity in the agrarian sector; on the basis of Morrill Act, public agricultural universities were opened. Developing on the basis of the opened opportunities, economic organizations did not only become more effective, but gradually changed the institutional framework as well [1].

However, understanding of the importance of education in economic development is not enough to form an effective institutional educational environment. An important objective is to choose the optimal characteristics of the education system, which are not always obvious.

Thus, according to the research on the role of social institutions in the implementation of investment and innovation models of economic growth by Harvard University professor F. Agion, secondary education plays a crucial role for the country's ability to borrow innovations, while higher education contributes to developing new technologies. Therefore, countries with transit and catching-up economies are encouraged to invest in higher education.

In addition, there are a number of issues related to the content and principles of education, the degree of integration of the education system into global space.

Thus, the complex problem that should be solved is the conceptual and methodological support of the coordinated development of the economy and education as social institutions, which includes:

- the design of the model of education adequate to a new stage of technological development (the sixth technological mode / the fourth industrial revolution);
- the identification of the parameters of the model of education which is relevant to the role of the country in the world division of workforce; taking into account national interests and global integration of the country's economy into the world economic and educational space.

**Objectives of the article.** The aim of the research, taking into consideration the above, is to substantiate the conceptual approach to the choice of parameters of education as a social institution at the level of an individual country during the cyclical technological transformation of the global economic space.

**Presentation of the main research.** In order to conceptualize the characteristics of the education system, which is complementary to the technological transition, it is advisable to apply two analytical models: P. Stefanenko's model of the formation of the didactic system and the model of country positioning according to the criteria of “the level of development of the sixth technological mode (TM) – the predominance during the integration in the world educational space (ES)”.

*Stefanenko's P. model* is a model of a didactic system, based on a system approach with allowance for control parameters, invariant and nonspecific parameters of the order of the given system. The didactic system (or the training system), according to P. Stefanenko, is a combination of strategic and operational components. The strategic components (or the system's genotype) include strategic principles and means of content transfer (Fig. 1).

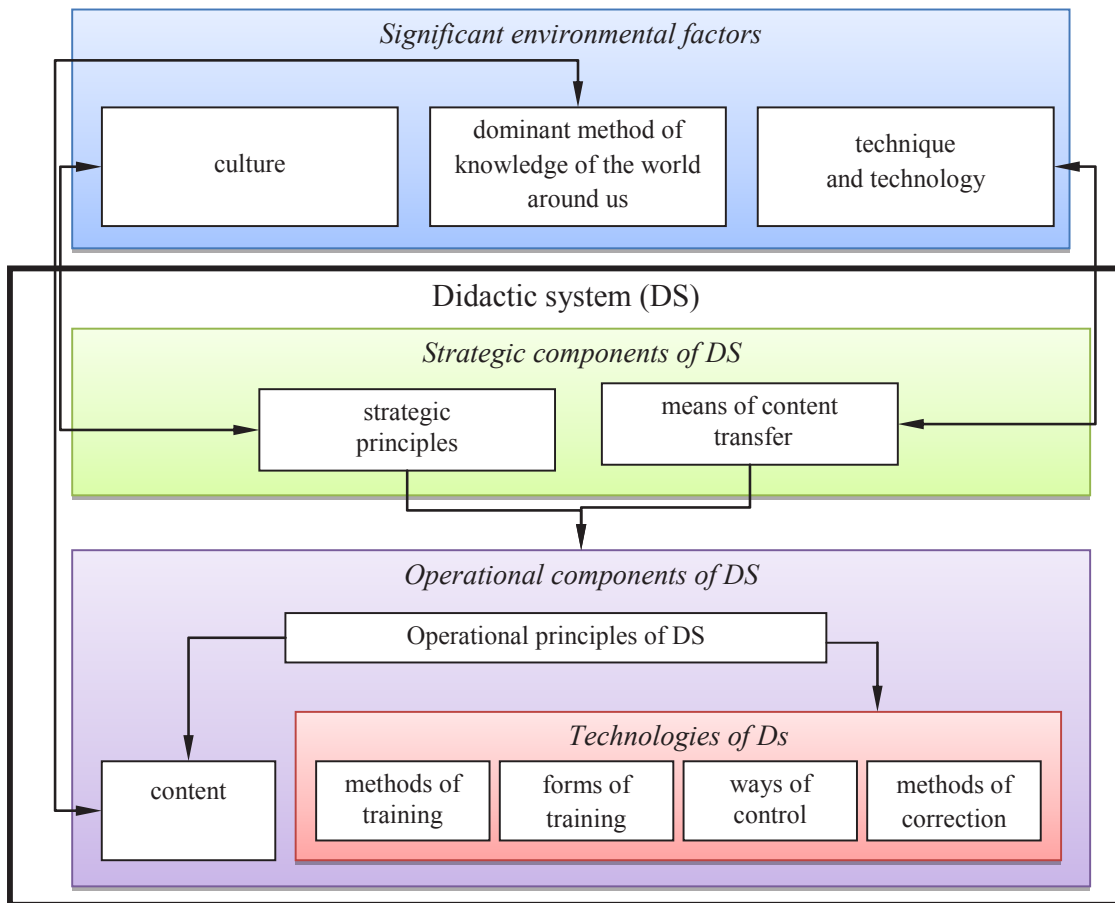


Fig. 1. Structure of didactic system [5]

Strategic principles are formed under the influence of cultural features of society and represent the characteristics of:

- a management style: authoritarian – democratic;
- the level of interaction of learning process: low – high;
- a dominant cognitive process, which is used to transfer the content of learning: memory – thinking.

Means of content transfer can be non-verbal, verbal, video and audio, computer technology.

The operational components of the didactic system include “content of DS” and “technologies of DS”, represented by methods, forms of training, ways of control and correcting the process of content transfer.

According to P. Stefanenko’s conception, the formation of the structure elements of the didactic system is determined by the leading parameters: the culture of society, the world view as the dominant way of cognition, and also the development of science, technology and technology [5].

The actual transformation of the model of the didactic system is conditioned by the development of technique and technology, which will inevitably affect the content of education, the means of content transfer. Furthermore, prerequisites for a higher level of individualization of the learning process, for its interactivity, will be formed. As part of the learning process, new content transfer tools will require the development of new

methods and forms of training, ways of controlling and correcting knowledge.

Thus, it is possible to generate the design of didactic system adequate to problems of 4 industrial revolutions/ the sixth technological way, whose universal model reflects dominating influence of technologies as the environmental factor undergoing essential transformations (Table 2).

Considering the fact that formation of a new technological way is characterized by labour liberation in those activities where algorithm actions skills are required, the priority in a didactic system is given to development of creative thinking and corresponding kinds of educational activity.

However, the use of a universal model for the formation of a didactic system within a specific national space requires consideration of the condition of economic and social development of a given country.

In the framework of the international trade theory, it is known that the further the country is from the advanced edge of technological development, the greater the level of protectionism of domestic production is necessary for the catching-up forward movement. The same principle can be considered for the education system. The further the education level of the population of the country is from the advanced civic civilization development edge, the greater correction will be required when establishing the global/national proportion in the

Table 2

The design of a didactic system adequate to problems of 4 industrial revolution/the sixth technological way: universal model

Parameters of Didactic system	The characteristics corresponding to 4 industrial revolution/to the sixth technological way
Strategic principles	Management style: democratic. Level of interactivity of training process: high level. Dominating informative process which is used for transfer of the training content: adapted to the trained. Training time: life-long (continued learning)
Means of content transfer	Computer technologies as priority. Access to primary sources – to generators of new knowledge. Cooperative forms of interaction in the course of training. Differentiation of functions of knowledge generating and of training courses design (cognitive science, behavioural sciences)
Operational principles of DS	(Additional, corresponding to 4 industrial revolutions): - principle of pedagogical expediency of IT application; - principle of safety of the information circulating in didactic system; - principle of conformity of training technologies; - principle of training mobility
Content	Corresponds to principles of a postclassical stage of science development: - an integrity and complexity paradigm, interdisciplinary way of problem solution (at a stage of creative mastering of knowledge)
Methods for training	Accent on research and problem methods for training taking into account depreciation of algorithmic knowledge and robotization of reproductive activities. Training methods adapted to the trainee taking into account several levels: - individual qualitative (character of information mastering); - individual intellectual (speed and quality of information mastering); - cultural (training methods as cultural patterns). Interactive methods for training
Forms of training	Depending on studied discipline taking into account cultural differences (individual/collective)
Ways of control	Depending on a grade level: from intellectual systems at the first stages to an expert estimation of creative works – at final grade levels
Methods for correction	Individualized, taking into account background of training process

content of education. The same applies to the economic development.

Fig. 2 shows the model of country positioning in accordance with the criteria “the level of development of the sixth technological mode (TM) – the predominance during the integration in the world educational space (ES)”.

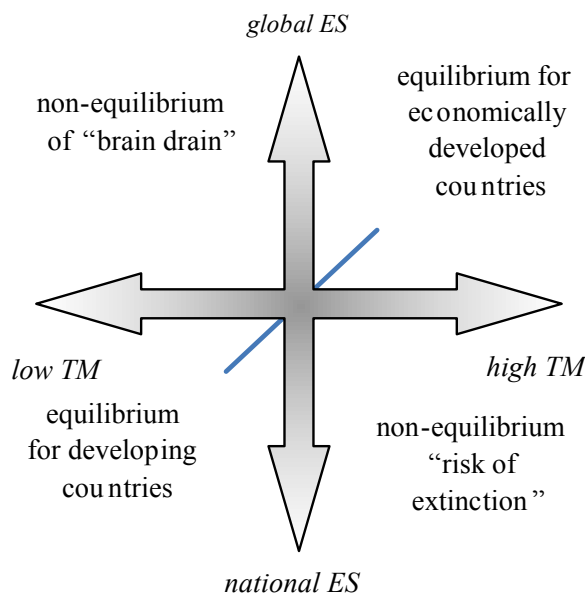


Fig. 2. The model of country positioning according to the criteria “the level of development of the sixth technological mode (TM) – the predominance during the integration in the world educational space (ES)”

Countries that are leaders in the development of modern technologies of the sixth mode, which will form the basis of a new long-term cycle of economic development of the world economy, will be located on the right of the horizontal axis. Countries whose development level is lower will be located on the left.

The vertical axis reflects the dominant education system of the country:

- the dominance of the global educational space postulates the active involvement of citizens through distance learning, international educational programmes in the global educational space, access to modern training courses of world leading universities;
- the dominant feature of the national educational space indicates a high proportion of traditional education within the framework of one state, the orientation of the content of education is more to the needs of the national economy than to the mastery of advanced international knowledge, skills and habits.

In the presented matrix for positioning, two equilibrium and two non-equilibrium positions can be distinguished, taking into account the following situation: the higher the level of technological development of the country is, the greater the level of integration into the world educational space without losing equilibrium is. Equilibrium is the level of coherence in the development of the national economy and education as a social institution.

So, a country with a low level of technological development and a high level of integration into the world educational space falls into the risk zone of “brain drain”. Having access to modern knowledge, the most talented youth with a high probability will use this resource as an opportunity for emigration.

On the other hand, a country with a high level of technological development, which is situated in the closed educational space, falls into the “risk of extinction” zone, the characteristic of any closed system. Although this position is more stable in the short-term perspective than the previous one, it steadily reduces the opportunity for growth in the long-term period. If the state is a leader of innovative and technological development, the isolationist position will help to increase the level of inequality, which, if certain critical points are reached, will inevitably lead to unpredictable development options in the turbulent scenario.

It is important to notice that the problem of balance search between global and national educational space is not only technical, toolkind, but also conceptually-caused. Thus, it demands the coordination with strategy of social and economic development of the country, with conceptual vision of the future in terms of “centre-periphery” model. Besides, the process of education system transition from one steady condition into another is inevitably characterized by transitive, hybrid [6] forms.

In the case of applying the presented models to a specific socio-economic system, the proposed analytical tool allows determining the basic parameters of the education system that are optimally aligned with the goals of economic development during the technological revolution.

**Conclusions and recommendations for further research.** The further direction of the study of coordinated development of education and economy as social institutions is the development of methodological support for the choice of the parameters of the education system which should include a set of indicators that determine the design of the education system that can increase the efficiency of the transformation of the national economy.

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**Мета.** Обґрунтування концептуального підходу до вибору параметрів освіти як соціального інституту на рівні окремої держави в період циклічної технологічної трансформації глобального економічного простору.

**Методика.** Системне моделювання, системний аналіз і дизайн актуальних характеристик системи освіти, адекватної стану національної економіки й вимогам якісної технологічної трансформації глобальної економіки.

**Результати.** Розглянута проблема позиціонування національної економіки у глобальному економічному просторі в період зміни технологічних укладів чи четвертої промислової революції. Обґрунтована роль системи освіти в перехідні періоди економічного розвитку як інституту, що прискорює технологічний прогрес. У рамках теоретичних положень інституціоналізму із застосуванням системного аналізу сформовано концептуальний підхід до вибору актуальних характеристик системи освіти з урахуванням стану національної економіки. Проведена інтерпретація положень моделі дидактичної системи в термінах економічного розвитку з урахуванням глобальних технологічних трансформацій. Аргументовано концептуальний підхід до вибору структури системи освіти в діапазоні „глобальне – національне“ та охарактеризовані детермінанти цього вибору.

**Наукова новизна.** Обґрунтовано концептуальний підхід до реалізації дизайну системи освіти, метою якого є підвищення ефективності адаптації національної економіки до глобальних технологічних трансформацій.

**Практична значимість.** Полягає в тому, що запропонований концептуальний підхід є основою для розробки методичного забезпечення погодженого розвитку економіки та освіти як соціальних інститутів, що включає: пошук моделі освіти, адекватної новому етапу технологічного розвитку (шостому технологічному укладу/четвертій промисловій революції); виявлення параметрів моделі освіти, адекватної ролі країни у світовому поділі праці – урахування національних інтересів і глобальної інтеграції економіки країни у світовий економічний та освітній простір.

**Ключові слова:** економіка, освіта, інститут, технологічний уклад, промислова революція, глобалізація

**Цель.** Обоснование концептуального подхода к выбору параметров образования как социального института на уровне отдельного государства в период циклической технологической трансформации глобального экономического пространства.

**Методика.** Системное моделирование, системный анализ и дизайн актуальных характеристик системы образования, адекватной состоянию нацио-

нальної економіки і вимогам якості технологічної трансформації глобальної економіки.

**Результати.** Розглянуто проблему позиціонування національної економіки в глобальному економічному просторі в період зміни технологічних укладів або четвертої промислової революції. Обґрунтовано роль системи освіти в перехідні періоди економічного розвитку як інституту, що прискорює технологічний прогрес. В межах теоретичних положень інституціоналізму з використанням системного аналізу сформульовано концептуальний підхід до вибору актуальних характеристик системи освіти з урахуванням стану національної економіки. Проведено інтерпретацію положень моделі дидактичної системи в термінах економічного розвитку з урахуванням глобальних технологічних трансформацій. Аргументовано концептуальний підхід до вибору структури системи освіти в діапазоні „глобальне – національне“ і охарактеризовано детермінанти даного вибору.

**Наукова новизна.** Обґрунтовано концептуальний підхід до реалізації дизайну системи освіти

якщо метою є підвищення ефективності адаптації національної економіки до глобальних технологічних трансформацій.

**Практична значимість.** Состоїть в тому, що запропонований концептуальний підхід є основою для розробки методичного забезпечення узгодженого розвитку економіки і освіти як соціальних інститутів, що включає: пошук моделі освіти, адекватної новому етапу технологічного розвитку (шостому технологічному укладу/четвертої промислової революції); виявлення параметрів моделі освіти, адекватної ролі країни в світовому розподілі праці – урахування національних інтересів і глобальної інтеграції економіки країни в світове економічне і освітнє просторі.

**Ключові слова:** економіка, освіта, інститут, технологічний уклад, промислова революція, глобалізація

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## ONTOLOGICAL APPROACH TO QUALIFICATION MATCHING BASED ON COMPETENCES: MODEL AND METHODS

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## ОНТОЛОГІЧНИЙ ПІДХІД ДО СПІВСТАВЛЕННЯ КВАЛІФІКАЦІЙ НА ОСНОВІ КОМПЕТЕНЦІЙ: МОДЕЛЬ І МЕТОДИ

**Purpose.** Developing a matching method for the qualifications specified by different national and international qualification systems. This matching is an important part of efficient semantic retrieval of complex information objects, particularly, for the purpose of the European and National Qualifications Frameworks transparency.

**Methodology.** The proposed approach to qualification matching is based on ontological analyses of knowledge about human competencies. Ontologies provide formalization of such knowledge, its interoperability and powerful mechanisms for its automatic processing.

**Findings.** We develop an ontological model of qualifications for structured representation of various complex information objects (humans, disciplines, specialities, organizations, etc.). The ontological representation of competence knowledge about these objects provides their automatic matching.

**Originality.** Scientific novelty of this work deals with the use of atomic competencies as the main component of the original ontological qualification model that becomes an instrument for solving the complex scientific problem of qualification matching. Information about atomic competencies represented by this ontology can be automatically retrieved from semantically marked Web resources.