Life cycle analysis of engineering education systems in different countries

Oleg Figovsky[1], *William Zadorsky*[2]

[1] *Alliance of Peoples of the World, Israel*
[2]*Ukrainian State University of Chemical Engineering, Ukraine*

Аннотация: Life cycle analysis of engineering education systems. Engineering education in the leading countries. Deep crisis of Ukrainian and Russian engineering education.
Ключевые слова: education in different countries, life cycle analysis of education systems.

Not so long ago, engineering education in the former USSR was at one of the highest in the world. And today, in many scientific and industrial centers of the United States, for example, in Boston, in Silicon Valley, Russian is often heard. But already about 10 years ago, guys from India appeared in the leading research teams, primarily in the IT profile, and in the post-Soviet space and, above all, in articles about Ukraine, they more often note a significant decline in the level of education, especially engineering. Among the reasons for the decline in the quality of education in Ukraine, the collapse of the country's real economy is also often indicated, a covid pandemic, long-term tragic events in Donbass and Crimea... The authors ventured to suggest that the degradation of the scientific and educational system in Ukraine is associated with rejection of the laws of systems development. To analyze the causes and make recommendations on possible methods for improving the situation, we will try to use general methods of system analysis and use the techniques of analyzing the life cycle of systems.

Information for thought

China. The question of how to train a cadre of highly qualified engineers is the most important state task that the Chinese authorities have set for the system of higher engineering education. Today China is already a country of progress and innovation. China has the largest robotics market; the country's territory is crossed

by the latest trains at a speed of 487.3 km / h; TOP 5 global smartphone manufacturers include 3 Chinese companies.

China's technical universities have some of the best material wealth in the world. The most rated technical universities are included inconsortium China Campus Networkand are open for admission to all comers [1]. So, Zhejiang University is a comprehensive scientific university with a high share of influence in China and the world [2]. The university has its own Science Park with an area of 113 hectares, there are 100 high-tech enterprises and 7 rating hospitals. The research fund of this scientific university has an annual budget of over 3.3 million yuan.

It is worth drawing the reader's attention to the fact that, in China, the idea of a synergistic unity of education, science and real production has already been implemented. Hereinafter, the authors deliberately highlight the provisions in the development of education systems that can be used to improve the education system in other, less successful countries.

As V. Kuznetsova and O.Mashkin (Moscow State University named after M.V. Lomonosov), modern China has become a country with the largest system of higher education in the world [3]. But simultaneously with the course on the development of mass higher education, China is also forming a cluster of elite universities, the goal of which is to reach leading positions in the rankings of the best universities in the world. The Plan of Measures for the Revival of Education in the 21st Century adopted at the end of the 20th century and the joint decision of the CPC Central Committee and the State Council of the People's Republic of China "On deepening education reform and comprehensive assistance in promoting quality education" laid the foundation for legal regulation of the modern system of national universities. All state universities were divided into two main categories: central (category "A") and local (category "B / C") subordination. Universities under the control of central departments were turning into platforms

for testing various models of organizing education to improve the quality of education with a focus on achieving the best world standards. A number of Chinese universities also actively cooperate with foreign universities, offering a variety of educational programs, including dual degree programs. Currently there are 2 389 joint educational projects with foreign universities, which involved about 600 thousand students. We draw the readers' attention to another important feature of the management of Chinese education and science - the unity of the administrative and political decisions adopted by the CPC Central Committee and the State Council of the PRC [4]. It is unlikely that this will be possible, for example, in Ukraine, where it is registered and political decisions are made immediately.

In the 13th five-year plan of the PRC (2016-2020), further directions for the development of the national education system were outlined within the framework of the strategy for building a knowledge economy [3,4]. The official goals of the strategy for building world-class universities and disciplines have been identified as: promoting universities and academic disciplines with the corresponding potential, among the highly ranked at the world level; accelerating the development of the higher education management system and modernizing management capabilities; increasing the level of innovation in personnel training, research, social services and culture in the structures of higher education; transformation of institutions of higher education into an important source of research and technological innovation, advanced ideas and culture, the basis for the education of talented citizens in all areas. Project identified three stages in the implementation of the established goals:

· by 2020g. form a group of world-class universities andacademic disciplines responsible the highest educational standards...

· by 2030g. increase the number of universities andacademic disciplines recognized as the best inthe world (including notless than 6 out of Top 9 Chinese

Universities in top 15 best in the world of universities), to achieve a significant improvement in the quality of national higher education.

· by 2050g. turn Chinese higher education into world leader...

Unique Thousand Talents Plan (TTP) Programor the Thousand Talents Program, to which one of the authors of this article was also invited, was established in 2008 by the central government of China to recognize and recruit leading international experts in the fields of scientific research, innovation and entrepreneurship [5]. Both the United States and Canada have warned that China intends to use the scientists involved in the plan to gain access to new technologies for economic and military advantages.

Germany. German technical education has always been conservative (a revolutionary approach is very difficult in education - author), shaping today's culture with the ability to use the knowledge of the past tense with the needs of today and with the search for ways to the future. In the German education system, the following can be attributed to the success of reforms: 72% of the university and 95% of institutions agreed to implement the reform, and the connection of universities with the German accreditation system allowed not reducing the quality of education [6]. Parametrization of specialties also arose: modules, credit points, academic load, diploma supplements, and an exam system appeared. The demand for bachelors in the German labor market is high, since often a super-qualified specialist is not required, but an understanding of the specialty and responsibility at work is required. Germany is a country that has historically played a leading role in the development of industry in Europe.

According to Wilhelm Humboldt [7], "... a characteristic feature of higher educational institutions is that science is always considered here as a not yet fully solved problem, and therefore higher education invariably remains in the process of research." Among the main conditions for the development of the German economy are the growth of production and consumption, dependence on imports of

raw materials and energy carriers, rising prices for raw materials and energy carriers, instability of imports of raw materials and energy carriers, stringent requirements of the Kyoto Protocol. This also includes an increase in wages and social spending and an increase in demand for innovative technologies in the global market.

France. France has the largest proportion of science and technology graduates aged 20-29 in Europe. According to Eurostat, there were 207 technical graduates for every 10,000 graduates aged 20-29 in France, 175 in the UK, and 114 in Germany.

In 2007, France undertook a higher ***education reform and science by changing the organization of universities and making them more open to the business sector***. Today universities conduct their own policy of scientific, budgetary and ***human resources and also manage their property***... Now they are faster and it is easier to recruit employees, create new training courses, build partnerships, create university funds and use their funds. Since January 2011, about 90% of French universities have decided to go offline [8].

France focuses on the export of higher education, going in two ways: the traditional export of national education in the form of specialized university centers and inter-university cooperation (installation of specialized centers in the universities of newcomer countries) [8, 9].

Great Britain. ***The engineering and technology sector makes a huge contribution to the UK economy - 27.1% of GDP***. 66.3% of graduates of engineering and technological faculties found a permanent job in their specialty in the first six months after graduation. Specialists in STEM (Science, Technology, Engineering, Maths - science, technology, engineering, mathematics) receive one of the highest salaries (£ 68,539 per year with a national average annual income of £ 26,500) [10-14].

Chemical Engineering. This young engineering industry combines natural sciences (chemistry, physics and biology) with mathematics and economics. He is studying how to get products from raw materials and chemicals in various (far from only chemical industries), suitable for use in various areas of life. Further, the reader will understand why the authors have highlighted this thesis.

Israel. The authors have covered modern engineering in Israel earlier (see, for example [15-18]). Israel today is one of the three leading countries in terms of the share of the educated population - it is here 49.9% of citizens (according to the Organization for Economic Cooperation and Development OECD for 2021). The educational system in Israel is known for modern approaches to the learning process at all levels. Graduates of Israeli higher education institutions are qualified specialists who have no problems finding employment in the most prestigious organizations around the world. Israel's Best University of Technology for 2021 - The Technion ranks 6th in the world among higher education institutions that create the most favorable conditions for research and innovation. Ranked 8th among the world's technological universities that support Nobel Prize-winning scientists. Today there are 3 Nobel laureates working at the Technion. In 2020, the Technion established its subsidiary university in China, the Guangjong Technion, with the faculties of Chemical Engineering, Materials Science and Scientific Engineering, Biotechnology and Food Engineering, and Mathematics and Computing.

Netherlands. ***The Dutch are known for their innovation and creativity, and their education system is renowned for its international character and problem-based learning style***. There are 14 state-funded research universities and 41 universities of applied sciences in the country [19].

In the context of globalization, environmental volatility, demographic shifts and migration, the Dutch Universities of Technology have focused on lifelong learning and the development of transversal skills (*Transversal competencies are*

skills and knowledge related to a wide range of professions and industries. They are also defined as core, universal or 21st century competencies. - Wikipedia) in the system of engineering education. Transversal competencies are becoming vital in the hyper-connected world of the "knowledge society" driven by globalization, digital technologies, global competition and artificial intelligence.

USA. Students planning to study engineering in the United States know that Engineering is a rapidly growing area with great career prospects both in the United States and abroad. According to all international rankings, Massachusetts Institute of Technology (MIT), Stanford University, California Institute of Technology and UC Berkeley top all the rankings when it comes to engineering programs.IN Engineering has a wide range of specializations [9]. The most high-paying engineering areas in the United States are petroleum engineering, electrical engineering, computer engineering, chemical engineering, civil engineering, mechanical engineering, aerospace / aviation engineering, Genetic Engineering. Of the 300 universities in the chemical engineering rankings, almost a quarter (74) are in the United States. Of them16 are among the 50 best universities in the world.

The top 6 US universities in chemical engineering include: Massachusetts Institute of Technology (MIT), Stanford University (Stanford University), University of California, Berkeley (UCB), California Institute of Technology (Caltech), Princeton University (Princeton University), University of Wisconsin-Madison (University of Wisconsin-Madison) [9].

Massachusetts Institute of Technology (MIT) leads the ranking of the best universities in many areas of knowledge and other top chemistry universities. What is the reason for this? Apparently, it is not at all in the fact that both authors of this article are chemists and have devoted their lives to the development and, most importantly, the practical implementation of their scientific successes achieved precisely in the chemical sector of science and economics. Perhaps the correct explanation is that since the time of alchemists, chemists have tried to get to the

bottom of the nature of things and phenomena, if we operate in terms of systems analysis, they worked at the deepest layers of the system of hierarchical levels - molecular and supramolecular structures. This made it possible to formulate a number of laws, which were then successfully used by all areas of science and industries associated with the processing of a wide variety of raw materials. It is no coincidence that today many leading scientists and specialists in various fields of activity also have a chemical education [9].

The basis of the state innovation policy of developed countries is the creation of conditions for the activation of science and innovative technologies through the introduction of market management principles. The share of people employed in the field of innovative technologies: Germany - 27.7%, Japan - 23.5%, Italy - 20.4%, USA - 15.5%, and the share of the added value of the innovative technologies segment in Germany is 27.9%, Japan - 25%, Italy - 20.7%, USA - 18% [7]. The distribution of budgetary funds is carried out only through the scientific community. At the same time, the European Union is the main financier of scientific research. Open days are held at universities and scientific organizations - everyone can come and see what is being done specifically and ask and ask questions, since the taxpayer is the basis of the life of German society. There are several scientific communities in Germany: German Research Society, Max Planck Society (80 institutes, 12 thousand employees), Helmholtz Society (15 research centers, 26 thousand employees), Fraunhofer Society (56 institutes, 13 thousand employees). Leading ministries and government agencies are launching all new educational programs, with particular attention to the grant system [7].

The list of successes of Western higher education can be continued, but it is already clear that there are alternatives to improving not only the quality of general engineering and fundamental training, but also the professionalism of graduates due to their immersion in the learning process in the real world of production, capable of carrying out the complex process of restoring the real

economy of the country, no, and that it is necessary to give universities the right to determine the forms and content of their synergistic relationship with industry and science.

In our opinion, this is difficult to implement today, but there is no doubt that significant changes in the former Soviet republics of engineering education are necessary. And you need to start with the rejection of “monkeying” (in Ukraine it is called “mavpuvannyam”), in which, to please some consumers of free specialists for them, a stupid “accounting” Bologna system is introduced, in which, instead of direct contact between the teacher and the student, formal level testing is used knowledge, generally abandon the familiar to all the term "engineer", replacing it with the beautiful, but unaccustomed terms "bachelor" (under-trained specialist) and "master" (under-trained scientist).

Education clustering and synergetics

Solving the issues of sufficient funding for education and abandoning the Bologna system are far from all. One of the main conditions for the transition to innovative engineering education, according to many scientists, for example, I.G. Shamshina (FEFU) is updating the methodology and content of engineering education based on the trends and approaches of modern science-intensive engineering within the framework of building a single national cluster "Engineering Education - Science - Industry - Innovation" of the emerging innovative knowledge economy. Identification of the best foreign analogues of educational programs, best practices, such as the implementation of real research, R&D and R&D at senior courses by orders of industrial enterprises, the integration of advanced industrial concepts and technologies, ideas and approaches of world leaders into the content of courses,

On the other hand, it is necessary to develop university science so that it participates in solving the national economic problems of developing the real economy, working on the topic of academic and industrial research institutes with

the participation of scientists, teachers and university students who carry out real course and diploma projects.

And, finally, it is necessary to create and actively participate in the business structures of the university (industry laboratories and institutes, business incubators, technoparks) at the graduating department or faculty working on topics related to the development of the country's economy. On this basis - the creation of dual education, institutions of residency or internship by analogy with medical education.

This is the very cluster approach in action, which will allow solving many problems of reforming the destroyed education and science of Ukraine and other post-Soviet countries. Outlines of such clusters began to appear in Russia. In Ukraine, they would be more successful, especially due to the fact that large enterprises of the real economy are almost completely destroyed, and the country, whether the “servants of the people” wants it or not, will have to move on to the creation and development of small and medium-sized businesses, for which such clusters would be a great area of activity.

If a cluster system is created with the participation of educational institutions in it, academic mobility will certainly develop, which is widely used in world practice, when a student, postgraduate student, teacher can move from one city to another, from one country to another, get the necessary information, master modern methods, feed on ideas, develop professional skills, and return to your cluster to complete your startup. This can be practiced instead of the notorious, ineffective, often formal internship or advanced training - retraining both in the disciplines read and in innovative startups that are being performed.

It is worth reminding readers once again that the cluster approach is just a means of implementing the laws and rules of a relatively new science - synergetics, which in the case of higher education is of particular importance.Now in Ukraine, a period of escalation of the cluster approach has begun as a specific form of

implementing synergetic ideology and project management. Cluster terminology has migrated to numerous publications devoted to development issues (no matter what - the state, region, city, science, technology, production, water supply or sewerage systems, etc.). They write about clusters as about networked innovative structures, about systems of innovative industrial clusters, about local production systems based on network structures - clusters, etc., etc. If we dive into the essence of beautiful terminology, we can conclude that "clustering" is a combination of integration and cooperation designed to compete with globalization, where clusters are a synergistic form of integration of subjects. And cooperation is a form of interaction between these integrated clusters. But behind linguistic research, the theoretical foundations, strategy and tactics, theory and practice of clustering in economics, in science, in education in the development of innovative directions of its use are practically not completely covered. At best, the feasibility of using cluster approaches and the positive results of this use are discussed. Meanwhile, clustering is by no means a new direction of management. The first steps in this direction in the era of the personality cult and the activities of the first “clusterizer” have not yet been forgotten - they used to say “bloody” (now, it seems, rehabilitated, at least in the latest TV films) Lavrenty Beria. It was then that: Academgorodoks, technopolises, technoparks with prisons, with included in them industrial production and educational institutions, secret NKVD "Sharagi". Only many years after they showed their merits, unfortunately, based on repression, tank, missile, aviation, atomic, etc. clusters, other forms of manifestation of cluster synergistic policy have appeared, for example, polytechnic secondary schools with training and production workshops, most institutes of the National Academy of Sciences of Ukraine with pilot plants, large industrial enterprises with research institutes and design bureaus at them, universities with pilot plants and technological business incubators at them, factories - technical colleges (associations of universities and industries), etc.

And in technology, the modular approach - a variant of the cluster - made its triumphant march ... At least a part of the Flexible Automated Production Systems (GAPS) became modular (cluster) installations (BMU). Note that one of the authors of the article created the first industry cluster laboratory in chemistry. ONIL Block - modular installations (ONIL BMU) was created by the Ministry of Chemical Industry of the USSR in 1979 in Ukraine. It was this laboratory that developed not only specific chemical BMUs, but also the theoretical foundations of clustering. Here is just a list of theoretical developments of ONIL BMU in the field of clustering:

· theoretical foundations of the systems approach (then there was no science of "synergy" yet) to the creation of clusters and the synthesis of cluster systems,

· methods of combining and the foundations of synergy of combined modules (clusters),

· the theory of combining technological processes and creating flexible chemical engineering systems,

· basics of emergence effects and their use in block-modular systems,

· theoretical foundations of interactivity when combining and combining modules,

· fundamentals of the theory of flexibility and adaptability of modular (cluster) objects,

· methods for optimizing objects with combined technological processes based on system analysis, etc.

Clusters in other countries did not doze either. International experience has demonstrated at once four options for the cluster policy of power, depending on the role of the state:

· catalytic cluster policy, when the government brings stakeholders together and provides limited financial support for the project;

· supportive cluster policy, in which the catalytic function of the state is complemented by its investments in regional infrastructure, education, training and marketing to stimulate the development of clusters;

· directive cluster policy, when the supporting function of the state is supplemented by the implementation of special programs aimed at transforming the specialization of regions through the development of clusters;

· interventionist cluster policy, in which the government, along with fulfilling its directive function, takes over from the private sector the responsibility for making decisions on the further development of clusters and through transfers, subsidies, restrictions or regulation, as well as active control over firms in the cluster, forms its specialization.

In Ukraine, they are more concerned with another area of "cluster management". The main thing is that during clustering, the authorities again do not use the notorious "regulatory policy". After all, as soon as the authorities begin to regulate something, everything ends in nothing, as now the "regulated" medium and small business ends sadly.

At the same time, in Ukraine, they started working on clusters, apparently, in earnest. Sometimes we even talk about the immediate development of a National Clustering Program for Ukraine, about the emergence of a National system of innovative industrial clusters. What is this - another fashionable hobby for a beautiful term, the result of a burst of intellectual activity among our elite - “servants of the people”, or is it really a necessity caused by life? But, after all, not all innovations are good, and their implementation is not an end in itself, since very often they are only a MEANS for solving specific problems, for example, the now fashionable “digitalization”. Since the creation of clusters is not an end in itself, but only one of the effective organizational forms of work, the idea ofcreating a program of general "clustering" of the country is meaningless, because the task cannot be replaced by a means of achieving it.

System analysis and principles of synergy dictate the need to meet the requirements for matching the size of clusters to the scale of the level at which they are formed. Clusters at the state level cannot be comparable in scale with sectoral or regional clusters, and even more so with clusters at the microeconomic level. In this case, cluster management should use factors (levers) of influence, the characteristics of which must correspond to the amplitude - frequency characteristics of the levels of influence (the so-called "principle of correspondence" or harmony).

Market and education system

It would be necessary to change the task of mass clustering of the country to another - to ensure competent project management using proven project management mechanisms. Ukraine, like many other post-Soviet countries, has acquired the status of a country with a market economy, dominated by the market, not the government. In market conditions, clusters should become a means of implementing the market development mechanism. The problem of the role of power in solving the clustering problem still raises a lot of discussions. It is important for specialists not to give bureaucrats the leverage of the notorious regulatory policy. Instead, the authorities should direct their energies to:

• Formulation of the problem and INITIATION of the emergence of clusters.

• Creation of incentives and clustering mechanisms.

• Assistance in the creation of infrastructure - a breeding ground (educational institutions and their departments, which should be given the status of legal entities, networks of private entrepreneurs - business angels, technological business incubators, service centers).

• Legislative support of technology business.

• Incentives for positive results.

At the same time, one should not forget that the specialists needed to reform the real economy are expensive, very expensive goods, and today employers

usually get them free of charge. That is why employers, at least in Ukraine, are very weakly involved in reforming the country's education, given its immersion in the sea of a market economy. A lot of systems for training specialists have been worked out in the world, in the implementation of which specialists become a commodity and then everything falls into place. Here, and advancing the employer for training the specialists they need and loans from universities to students for scholarships and tuition fees with payment of the loan by future employers, etc.

Intellectual property is also a commodity in this market. Apparently, the end of industrial espionage, the reproduction of someone else's intellectual property without paying for its value, is coming. Today, even China, which has gotten to its feet thanks to the use of not its own intellectual property, and in the aforementioned program of 1000 talents, prefers not to invite foreign geniuses in order to take possession of their intellectual developments by hook or by crook, but begins to train its own geniuses in universities. Therefore, not the notorious implementation, but the commercialization (sale or commercial concealment) of an intellectual product becomes a priority in a market economy. Then, protection, protection of intellectual property becomes not an end in itself, but a means of ensuring sustainable development. At the same time, attacking management and marketing become the basis of modern commercialization strategies. Thus, the developed concept of modular (cluster) synergistic technology business is based on the use of: system analysis, project management, market mechanisms of management, reliance on medium and small businesses. At the same time, the main task of the activity is to facilitate the solution of the main strategic task in crisis conditions - the implementation of the principles of sustainable development with the solution of economic, social and environmental problems by focusing on the development of medium and small business and turning it into a technology business, using high innovative potential and market mechanisms. Management

based on system analysis, synergy mechanisms and modern information technologies.

Reform of higher education must be carried out taking into account the market economy of management. First of all, this applies to Ukraine, where the higher school has not yet begun to fulfill the already formulated new requirements for the specialists it graduates. Much also needs to be done to drive the integration of business innovation. Apparently, first of all, we need a state development program. In the entire civilized world, first of all, the concept of sustainable development has been adopted and is working for this. In Ukraine, for 30 years, they have not been able to create such an effective program. One in which not only is written how it should be, but also suggested how to achieve this. Secondly, in a totally corrupt Ukraine there are a lot of officials, committees, commissions, etc. With the help of their "regulatory policy" they can only slow down or prohibit innovation processes. We must not interfere, but help, create conditions for the development of technology business. And the market can and should implement the regulatory policy in a country with a market economy. Thirdly, we need a correct approach to the implementation of innovative projects based on world experience. Don't start with inventions. It is necessary to implement project management, that is, to create a competent project, and already for it an experienced manager will select specialists, inventions (an innovative investor!), and an investment investor from all over the world. And he will not forget about the entrepreneur who will implement the project. Those. the notorious and ineffective technology transfer should be replaced by an oppositely directed technology business based on the increasingly widespread project management in the world. This is how a microcluster of a technology business will turn out, which will allow the commercialization of worthy innovations without the fact that inventors perform completely unusual functions of project managers. The project is effective only when everyone in the microcluster is doing his own thing. And the

higher school should become not only a trigger mechanism, but also the main executor of the intellectual part of the technological business, providing it with personnel trained for this.

Wherein ***special attention should be paid to global trends in the development of engineering activities and modern international requirements for professional engineers...*** The solution to this problem should be associated not only with the creation of technical and technological universities of a new type, but also with the development and development of new educational programs closely related to the new tasks of universities to ensure their active and effective participation in transforming the real economy of the country. So far, unfortunately, the curricula of many universities in Ukraine represent a unity of unrelated disciplines like a patchwork quilt. This inevitably leads to poor assimilation of them, duplication of not only university, but even school information. One of the authors of the article has a successful and at the same time failed experience of creating such a new program of interrelated special courses. HSeveral years ago, a line of author's special courses was developed and read, based on the author's theoretical developments, patents, inventions (somewhere around 400 - 500): 1. Theory of technical systems, 2. Innovative engineering. 3. Optimization of chemical engineering. 4. Engineering and technology business. Textbooks, methodological instructions were written, presentations were made for all courses. Proposals for clusters with SME enterprises were formulated and prepared. And then this project was faced with the fact that a relatively new science came to higher education - synergetics. With the light hand of businessmen, who had mastered synergetics earlier than others in the merger and absorption of each other by various firms for the purpose of optimization, a wide campaign for the merger and absorption of universities and departments within universities began in Ukrainian universities. Undoubtedly, synergetics in higher education has the right to exist. The same cluster approach is typical synergy.

However, in this example, everything ended in failure. After the merger of the departments, the main in the chain is the theoretical course "Innovative Engineering", which focuses on the Concept of sustainable development and sustainability indices, analysis of the life cycle of systems, new regime and constructive methods for optimizing chemical technology, the development of students' creative abilities, a new synergistic method of invention, etc. ., was transferred to another teacher, unfamiliar with either the course or the history of the issue. Because of this action, the entire chain of special courses was destroyed. in which the main attention is paid to the Concept of sustainable development and sustainability indices, the analysis of the life cycle of systems, new regime and constructive methods for optimizing chemical technology, the development of students' creative abilities, a new synergistic method of invention, etc., was transferred to another teacher who was unfamiliar with either the course or with the history of the issue.

Continuity

In this article, we want to touch upon an important issue of the continuity of not only generations, but also scientific schools. It so happens that a leading scientist who has worked for many years in a scientific or educational team, when retiring or into another world, takes with him everything that has been created by him or with his participation. It is especially sad when the heads of scientific schools leave. Their number in higher education, at least in Ukraine, has significantly decreased, while the level has decreased. In foreign universities, this is considered wasteful - they save every crumb of experience, intelligence, innovation, for which they hire competent even elderly specialists, if their health allows, as consultants, mentors, scientific leaders of topics, etc.

Particular damage to scientific schools, of which there were a lot in one of the countries of high intelligence in Ukraine, was caused by an ill-conceived pension reform. The government decided to replenish the budget that was

completely empty due to corruption and the unprofessional leadership of the country by offering working scientists to choose one of two sources of financial well-being - wages or pensions. from labor wages, and an elementary act of theft was committed - the seizure of other people's money, earned not by you. Scientists are proud and touchy people. Most quit. The auditoriums were emptied - there was no one to lecture. The younger generation often never saw the factory entrance, many factories had already been stopped. Scientific schools were beheaded and disintegrated. However, the authorities very quickly got scared of the deplorable results of their activities and canceled the pension reform. But it was too late - most scientists found application for their high intelligence in other institutions and enterprises and did not return to the offenders. Here is an example of the negative effect of unwise synergistic actions.

Science and technology for youth

Today, completely different guys come to universities, at least in Ukraine, than they came at the turn of the century. They are often referred to as the lost generation. Those who have come across a secondary school in some way know that it has also become different, somehow not childish. The thing is that children are very sensitive to what is happening around them, and, unfortunately, unusual, not always joyful things often happen. Children's programs have practically disappeared from TV screens (except for disgusted old cartoons, they are shown a lot, even for some reason late at night, when children are sleeping peacefully, apparently want to further reduce the intellectual level of young people), as if children are not people and not the same members societies, like all of us, in the ecstasy of decommunization destroyed the pioneer and Komsomol organizations and did not replace them with anything. But man is a collective creature and only Mowgli grows up alone or in communication with animals. Gone are developing literature, translations of magnificent works of world literature (we will not touch on language problems in the article, they are very painful and their results are

unpredictable), excellent children's scientific and technical magazines, which had no equal in the world. Where are the role models, where ... Yes, you can go on for a very long time. But, most importantly, children pass through all the problems of adults, they see everything, understand everything. And now there is the Bologna system and distance education. But, after all, today these guys have grown up and come to power, have become "servants of the people." So is it any wonder at the sad results of their activities. Maybe it's time to start growing the next generation that can replace them.

After this sad paragraph, I would like to discuss, albeit small, but successes. We will not touch upon general issues of upbringing in this article. But in order to restore our ruined economy, higher education must graduate completely different specialists than it has been graduating in recent years. It is not often that we hear from our educational officials words about what they should be and do not hear at all how to achieve this. Quite different requirements for specialists have been formulated for the higher school, which supplies personnel for those real economies that, for various reasons, are in the stage of degradation, reform, stagnation, etc. There are enough of them in the post-Soviet space. For example, here is how I recently formulated the requirements for a Ukrainian specialist, leaving her post as Minister of Higher Education, the former head of the relevant Committee of the Verkhovna Rada Lilia Grinevich. The key competencies and cross-cutting skills of a specialist, in her opinion, are not only fluency in the state language, mathematical, general cultural, environmental and economic competence, but also enterprise, innovativeness, ingenuity, critical and systemic thinking, the ability to be creative, initiative, and the ability to manage constructively. emotions, assess risks, make decisions, solve problems. You cannot get off with slogans alone in order to switch over to graduating such creative specialists from universities in the shortest possible time. Again, a synergistic unity of universities and secondary schools is needed. So far, there are first positive

results. Professionally oriented classes and even entire schools appeared, working in contact with universities of the corresponding profile. The most successful work is in the field of information technology, perhaps that is why while in Ukraine there are still positive results in this direction and even “servants of the people” are seriously engaged in digitalization. Unfortunately, work in other areas is still extremely weak.

However, the Small Academy of Sciences has been operating in Ukraine for several years. It is led by young guys. She works with high school students and is quite successful. But, if you look at the work program of the school, competitions, olympiads, you cannot but pay attention to the fact that not enough attention has been paid to the development of creative abilities and not just development, but to teaching methods, technology of creativity. The importance of this is now recognized in China, the most intensively innovative country, with its Thousand Talents Government Program. The authors of the article are engaged in solving these problems a lot, but, unfortunately, only on a voluntary basis. The author's modern methodology for the creative development of youth and inventions has been tested in a youth center and one of the best lyceums. The method works successfully and turned out to be much more effective than TRIZ, ARIZ, etc. Why shouldn't the Ukrainian Ministry of Education and Science take upon itself the organization of such schools in the country, but for now, at least at the Small Academy of Sciences? Then it would be possible to recommend the winners of competitions for admission to the university corresponding to the direction in invention. In the meantime, the Chinese have become interested in this technique ...

Decomposition and analysis of the life cycle of educational systems

We discussed only a few, but perhaps the most important for the recovery of the real economy and further dynamic accelerated sustainable development of countries, issues related to education. The concept of sustainable development,

implemented in most countries of the world, is the main driving force behind the development of education systems, because without sustainable, constant growth of qualifications of specialists, the sustainable development of the real economy, and, therefore, the entire country, is simply impossible to implement.

To analyze the reasons for the degradation of education in some post-Soviet countries, primarily in Ukraine, it is necessary to conduct a systematic analysis. If we remember that, above all, education contributes to the development of the consciousness of a young person, then we will have to admit that the first and, perhaps, one of the most important features of education systems is their continuity, which was discussed above. In the case of education, and above all higher education, it will not be possible to act according to the International - “all pcrush to the ground, and then we are ours, we will build a new world”Even in the“ turbo mode ”of the Ukrainian authorities. First of all, higher education is preceded by school and preschool education, and very often the continuity between them is not taken into account. Psychologists believe that a child in humans is born with a poorly developed consciousness and, most importantly, only with the rudiments of knowledge of the language of communication, obtained when he was still in the womb and overheard her. This stage of development is often called "Mowglism" by Kipling. This is not the subject of this articles but nevertheless, let us remember that in the learning process, and a person learns, as you know, all his life, the forced replacement of the mother's language by the language of communication in the country of residence does not at all contribute to the rapid and high-quality development of a person for a number of reasons (if only because in a language new to a person there are simply no high-quality, and often low-quality, textbooks, reference books, scientific - technical, periodical literature and information). In this regard, apparently, the increasing Ukrainization in Ukraine does not at all contribute to the improvement of the quality of education.

The next stage of development is considered dogmatism, when a child is taught the basic rules of life, including communication with other people. At this stage, in many countries, especially the "post-season" ones, they "love" the offspring and forget to teach modern children the principle of reasonable sufficiency (maybe this is why so many corrupt officials with an all-consuming thirst for enrichment later grow up). Unfortunately, not only family and preschool education, but also secondary and even higher education, where the head of a young person is stuffed with a huge amount of random, unrelated knowledge, many of which he will never need in later adult life, sin with dogmatism. Fortunately, in many cases, dogmatism in more developed individuals is replaced by criticism, which, in fact, and is the basis for further, more independent development of a person with the transition to so-called creativity, that is, to the ability to generate new, more effective solutions (this is when future reformers and public leaders are born!). And even among the most developed and talented, well-trained young people (unfortunately, there are not many of them), this stage passes into the highest stage of development - constructivism, when solutions become more outlined in terms of the possibility of their use.

At present, more and more specialists in the real economy, and employees of higher education, believe that completely different specialists are needed in a market economy. The requirements for them were given above. Speaking about the compliance of the quality of specialists with the requirements of the revival of the economy of many countries, it should be noted that in specialized universities today there is a tendency to train a significant number of technologists and a significantly smaller number of equipment specialists. Meanwhile, the practice of restoring stopped enterprises with destroyed, obsolete, even dismantled equipment requires the opposite approach. The best universities in the world have long abandoned the training of "test tube" - technologists in favor of training mechanic -

technologists, i.e. technicians ("chemical engineering", they say in English-speaking countries).

Here is an example of the importance of such questions from the practice of higher education back in the USSR. One of the authors of the article then headed a large industrial laboratory of the Ministry of Chemical Industry at one university. The then Minister of the Chemical Industry L, A, Kostandov invited him to make a co-report at the expanded board of the Ministry (there were about 400 people from enterprises, and also representatives of the State Committee for Science and Technology, the Academy of Sciences, the Ministry of Education, industry research institutes) to the prominent domestic chemist, mechanic, technologist, cybernetics academician V.V. Kafarov on the problem of increasing the nomenclature of the country's chemical industry (in the USSR, chemical products were then produced only 16,000 names, and many foreign companies produced chemical products, the number of names of which was several orders of magnitude higher). I remember that the academician proposed to use cybernetics, which was rapidly developing at that time, to accomplish the task. The co-rapporteur objected, explaining that if you put the most modern computer on the AN-2 plane, it will not fly like TU-154. It is necessary, they say, new flexible equipment, new flexible flight technology, in addition to new controls. A lively, very sharp discussion ensued. The supporters of the second approach won. And then the Minister suddenly asked the co-rapporteur what his specialty was. Hearing that two (a mechanic and a technologist), asked the board members, technologists by profession, to raise their hand (10 people raised), IT technologists (5), economists (15) and, finally, mechanics (forest of hands, others). The surprised minister asked the representatives of the Ministry of Higher Education who were present at the collegium to investigate and draw conclusions.

And one more thing surprised me even then - the persistent attempt of the main speaker to exaggerate the importance of information technologies for solving

the assigned tasks. It is now the majority of specialists (except perhaps, except for the “servants of the people” in Ukraine, who stubbornly push for “digitalization”) have figured out that digital technologies are a wonderful effective tool for solving many problems, but only a tool, and by themselves without technology and equipment they do not create an effect (the object is replaced by a tool for its functioning).

The hierarchical ladder of the education system of the USSR connected the levels of various hierarchies with direct and feedback (to save space, we will arrange this ladder horizontally):

1. Central government <=> 2. Union Ministry <=> 3. Republican Ministry <=> 4. Universities <=> 5. Faculties <=> 6. Departments <=> 7. Teachers <=> 8.Students.

When such hierarchies are considered when optimizing technical or any systems, always one (rarely two or more levels) are limiting (s) and it is on him (them) that attention is focused when optimizing the system. The Union's education system turned out to be original. Here, firstly, almost all levels turned out to be limiting. But, in addition, it was noticed that the upper two levels turned out to be a structure where all the components are interconnected by direct and reverse cluster and synergistic (in this case, we should talk about the mutual influence of interacting systems) connections.

The reader can, if necessary, read about systems analysis, clusters and synergetics in the monographs of one of the authors [20, 21].

Indeed, the typical cluster structure was the 1st and 2nd hierarchical levels. The central government bodies belonged to the cluster-forming ones, and, of course, such organizations as the State Committee for Science and Technology, the State Planning Committee, Gossnab, the Academy of Sciences, and others, as well as, of course, the political power, belonged to the union ministries. The most important cluster uniting education, science and the real economy was actually

implemented. It has been shown more than once in the article that without such a cluster, not only the development of the country, but each component of the cluster separately is immense. Most researchers agree that it was this kind of management system that ensured the high rates and efficiency of the country's industrialization and the success in the development of the higher education system.

So, after the collapse of the Union, in the hierarchical chain of higher education in every post-Soviet country, including Ukraine, there were stages from 3 to 8. And ALL stages began to actively participate in the reform of the systems. In the absence of a CSD (Concept of Sustainable Development), the Ministry of Education and Science of Ukraine began to engage in some strange reforms that have nothing to do with training new types of specialists for work in the market. The Bologna system appeared, read about it above and in numerous articles by one of the authors, they came up with a lot of forms, introduced universal testing, some rating cards of students (like, they were darkened later), puffy reports, Scopuses - popuses for assessing the rating of teachers (so that then give 0.25 bets to everyone, regardless of Scopus or Kirsch), VNO is an assessment of the level of training of students with a total shortage of applicants, the merger and absorption of universities, faculties, departments, the emergence of a wild number of private universities, etc.). The first to figure out were students, the lowest hierarchical level. They turned out to be smarter than their teachers and voted ... with their feet. Today, many, if not most, children study abroad (the authorities did not hesitate to help them with visa-free travel).

And finally, a little about the life cycle of the higher education system. The cycle is analyzed by many scientists and specialists working in the systems of the real economy. The system of higher education is analyzed much less. They found that there are several successive stages of development:

1. The latent period until the official birth (there is no system as such yet, but it already exists and, most importantly, financial resources are already being spent

on it). This is similar to the latent period of pregnancy – the child is not yet there, but he is already in the womb and happy parents are already spending money to prepare for his birth.

2. Development (childhood, adolescence, youth) of the system.

3. System maturity.

4. The flourishing of the system.

5. Recession, degradation of the system.

They usually discuss one question - how to stretch points 3 and 4 - the maturity and flourishing of the system and as late as possible go to point 5 - the degradation of the system. In the case of Ukraine, the task is simplified. 1 and 2 points Ukraine passed along with the entire then still large country. But they hoped that the system would continue to work steadily in a market economy. But no, completely different economic laws work, the participants, especially the youth, have changed. This did not bother anyone. So we are reaping the benefits...

The reader will ask where the construct is. Why are we writing all this? And the recipe for brewing tea is simple - it will not be possible to move back along the trajectory of the life cycle - no one has yet succeeded in entering the same water twice. It is necessary from that point almost at the very bottom of the 5th section of the life cycle trajectory to start building a new system for completely new conditions for its operation. There is only one secret here - not to rely on higher hierarchical levels. They will not help, they are unprofessional. Most of them are the product of that very destroyed education system. You can only rely on yourself. It is necessary to include the collective intelligence, intelligence at the lower level of the hierarchical system - the department. To begin with, you need to FORCE the upper levels to provide departments, at least graduating, profiling, legal and financial independence, the right to choose managers, all the delights of decentralization, reduction to a reasonable limit of deans, administrations,

ministries. We will not write further, they may misunderstand and draw organizational conclusions.

As for the conclusions of the article, we have already made them, highlighting the most important findings in the experience of higher education in other countries and in our author's experience. If you copy all the highlighted proposals and give them on one page, you get an almost ready-made roadmap for the resuscitation of a higher school, at least for Ukraine. Well, you can still take some recommendations from our many articles published in periodicals and on the Internet, as well as in our books.

References

1. Konsorcium China Campus Network [Consortium China Campus Network]. URL: chinacampus.ru/.

2. CHzheczyanskij universitet [Zhejiang University]. URL: chinacampus.ru/universitety/ chzhetszyanskij-universitet.

3. Kuznecova V.V., Mashkina O.A. Obrazovatel'naya politika. 2019. №4 (80). URL: cyberleninka.ru/article/n/proekt-shuan-i-lyu-globalizatsiya-kitayskogo-vysshego-obrazovaniya (date assessed 28.06.2021).

4. Miheev V., Lukonin S. Obshchestvo i ekonomika. 2016. № 7. pp. 36-51.

5. Thousand Talents Plan. URL: max-k-studio.com/thousand-talents-plan (date assessed 23.03.2021).

6. Tekhnicheskoe obrazovanie v Germanii. Poluchenie tekhnicheskogo obrazovaniya v Germanii. [Technical education in Germany. Getting a technical education in Germany]. URL: allterra.ru/articles/177865/. (Date assessed 2020-11-24).

7. Rymova A.G., Smirnov V.V. Santekhnika, otoplenie, kondicionirovanie. 2014. T. 154, № 10. Pp.88-95.

8. Kuznecova E. Mashinostroenie. 2011. № 6. pp. 66 -74.

9. Sistemy podgotovki atomshchikov v SSHA, Francii, YAponii i YUzhnoj Koree. Upravlenie proizvodstvom [Systems for training nuclear scientists in the USA, France, Japan and South Korea. Manufacturing control]. URL: uppro.ru/library/personnel_management/training/podgotovka-atomschikov.html.

10. Chemical Engineering. URL: thecompleteuniversityguide.co.uk/league-tables/rankings/chemical-engineering.

11. Civil Engineering. URL: thecompleteuniversityguide.co.uk/league-tables/rankings/civil-engineering.

12. Electrical & Electronic Engineering. URL: thecompleteuniversityguide.co.uk/league-tables/rankings/electrical-and-electronic-engineering.

13. Mechatronics foundation degrees. URL: whatuni.com/foundation-degree-courses/search?subject=mechatronics.

14. Mechanical Engineering. URL: thecompleteuniversityguide.co.uk/league-tables/rankings/mechanical-engineering.

15. Satanovskij E., Figovskij O., Korneevskij S. V SSHA i Izraile vsya nauka delaetsya v universitetah [In the USA and Israel, all science is done in universities]. URL: radiovesti.ru/brand/61009/episode/1461572/.

16. Zadorskij V.M., Figovskij O.L. Nisprovergateli tradicij ili kak obuchit' innovatora [The Breakers of Tradition, or How to Train an Innovator]. URL: iee.org.ua/ru/publication/283/

17. Zadorskij V.M., Figovskij O.L. Inzhenernyj vestnik Dona, 2017, №3. URL: ivdon.ru/ru/magazine/archive/N3y2017/4380.

18. Zadorskij V.M., Figovskij O.L. Inzhenernyj vestnik Dona, 2017, №4. URL: ivdon.ru/ru/magazine/archive/n4y2017/4382.

19. Luchshie universitety Niderlandov dlya inostrannyh studentov. [Best Universities in the Netherlands for international students]. 2021. URL:worldscholarshipforum.com/ru/%D0%BB%D1%83%D1%87%D1%88%D0

%B8%D0%B5%D1%83%D0%BD%D0%B8%D0%B2%D0%B5%D1%80%D1%81%D0%B8%D1%82%D0%B5%D1%82%D1%8B%D0%BD%D0%B8%D0%B4%D0%B5%D1%80%D0%BB%D0%B0%D0%BD%D0%B4%D1%8B/.

20. Zadorsky V.M. Synergy in Engineering Chemistry. Means and methods. Just about the complex: Monograph. Palmarium Academic Publishing (02/08/2016). 396 p.

21. Zadorskiy V.M. Theory of technical systems. Optimization. Means and methods: Monograph. Palmarium Academic Publishing (24.05.2016). 364 p.