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METHODOLOGICAL BASES OF INNOVATIVE TRAINING FOR SPECIALISTS IN AREA OF NANOTECHNOLOGIES

Extended Abstract:

The performance of innovative training system aimed at highly intellectual specialists in the area of nanotechnologies for Kazakhstan's economy demands establishment and development of nanotechnological market in the country, teaching of innovative engineering combined with consistent research, integration of trained specialists with latest technologies and sciences at the international level.

Methodological aspects of training competitive specialists for nanotechnological field are specific. The paper presents methodological principles of innovative training of specialists for science-intensive industry that were realized according to grant given by the Ministry of Education and Science of the Republic of Kazakhstan.

Key words: Nanotechnology, innovative training of specialists, schools of sciences, intensive research activity, science-oriented technologies, integration.

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Introduction

Kazakhstan's nanotechnology market endures a difficult stage of the formation and the development, meaning the active interaction and participation of key institutes and innovative structures of the country. From the state the close attention and support appear to domestic developments and the started projects, which are really passing to production stage. For acceleration of nanotechnology development the Kazakh national nanotechnological initiative is put forward, which will supervise also questions of the university education being in direct link with innovative processes happening in national economy.

It is possible to claim that prospects of nanotechnology development will be determined in many respects by qualitative content of training system in concrete educational sector. Therefore, from the position of ensuring of scientific and technological breakthrough of the country, the system of preparation of highly intellectual specialists for science intensive industry is faced with extremely actual and complex challenge.

There is an urgent need of creation of new quality of the organization of structure and content of education, according to modern requirements of national economy and tendencies of international experience. Orientation on perspectives of nanotechnology development with taking into account world experience and those initiatives, which are undertaken by the state, will demand the development of corresponding educational sectors. That is necessary to determine training opportunities for preparation of

specialists for researches and developments in chosen direction of nanotechnological activity (for example, in nanoengineering, nanoelectronics, nanocomposites, etc.).

Actually, it is a question of ensuring of innovative training of highly qualified, competitive future specialists, which are capable to engage in large researches, effectively using high technologies. In this area the offer of Kazakhstan's educational system is very limited and insufficiently competitive. In Kazakhstan first issues of magisters and doctors for specialty «Nanomaterials and nanotechnologies» only began to be implemented.

Scientific search of optimal ways of the development of preparation system of highly intellectual specialists for key industries of economy (mainly, magisters and doctors) was based on the analysis of best international practices. Integration as a way of realization of updated training system of specialists in science intensive industry is the most effective way on the basis of development of international integration and partnership. On this occasion President of the country N. Nazarbayev was told: «according to examples of the European countries it is expedient to develop technological platforms, to create a common research network with participation of higher education institutions, research centers and business structures ...» (Nazarbayev, N. 2012)[1]. Integration in the sector of training of specialists for science intensive industry (in particular for nanotechnologies), allows better understand the innovative processes in science, technologies, education.

Thus, starting positions for substantiation of innovative training of needed specialists in nanotechnology field for Kazakhstan's economy are:

– the state and the development of Kazakhstan's nanotechnological market;

– innovative nature of future specialists training for nanotechnology;

– integration as a main way of realization of innovative training.

Methodological substantiation of given provisions will allow at methodical level to provide innovative training of competitive specialists in nanotechnology field for developing segment of economy. In the paper the essence of theoretical provisions is disclosed in line with researches that

[1] Speech of the President N. Nazarbayev at The IX Forum of border cooperation of the Russian Federation and the Republic of Kazakhstan. Pavlodar. September. 2012. *Expert of Kazakhstan № 38–39*, 24 Sept – 7 Oct. 2012. – p. 28–29.

were conducted by authors by the order of the Ministry of Education and Science of the Republic of Kazakhstan (MES RK)[2].

The state of kazakhstan's nanotechnology market

Today Kazakhstan's market of nanoproducts isn't still created fully, but there are producers and developers of nanotechnology products, and for the last decades their quantity steadily grows according to the growth of institutional order for innovative production. Any nanotechnology development causes huge social effect because it demonstrates the progress of a domestic production and market prospects of the country.

Joint projects on the basis of cooperation of Kazakhstan with Russia as the main economic partner of the country play the important role in creation of market productions in nanotechnology. Portfolio of joint Russia-Kazakhstan projects assumes both very short terms of production, and terms till five years depending on scale, for example: projects in the field of solar power (production of solar batteries of land and space basing), mechanical engineering (production of water purification equipment on the basis of nanotechnology), oil refining and production of bitumen (production of modern valves for pumps with nano-covering). Construction of the plant for production of new organic mineral fertilizer «Bioplant Flora»[3] that is created on the basis of nanotechnological achievements in agriculture is begun in North Kazakhstan area with participation of partners from Russia.

The entry into the world market gives the development of Kazakhstan's initiative in nanoelectronics (Suleimenov, I.E., Mun, G.A., Polyakov, A.I. & Yeligbayeva, G.A.). According to opinion of Kazakhstan's scientists, «now in Kazakhstan the nanoelectronics represent a certain bank of ideas, which are used only in insignificant degree in industry». Scientists consider «this circumstance presents opportunity for Kazakhstan to take own place in international division of labor in given field of science, because the

[2] Research project by the order of MES of RK «Methodological fundamentals of educational integration in the context of development of postgraduate technical education system (on the example of specialty «Nanomaterials and Nanotechnologies»)». – Almaty: KazNTU named after K. Satpayev, 2012–2014.

[3] Danilova, A 2010, 'Kazakhstan: nanotechnologies will make revolution in agriculture', *Kazakh Zerno. Kz,* № 37 (65), 11 May – http://www.kazakh-zerno.kz/.

countries possessing various level of technical development in nanoelectronics while are in approximately identical situation» (Ergojin, et al. 2010, p. 90). Physical chemistry of hydrophilic polymers is considered as scientific basis of Kazakhstan's initiative in nanoelectronics. «In given field in the Kazakhstan physical and chemical schools traditionally hold position that is inferior to none in researches of the most developed countries. So, it is possible to realize breakthrough on the corresponding base» (Ergojin, et al. 2010, p. 90). Achievements of scientific schools in the field of hydrophilic polymers are considered as a reliable basis for the subsequent steps in nanoelectronics areas. Projects of creation of nanorobots or nanocomputer on quasi biological basis serve the confirmation of that. Such nanorobots represent the analog of transport RNA, allowing to write down information into nanostructures (the data recording is reached due to formation of the arrangement of atoms on the surface). Their basis is the complex that is created with incentive sensitive polymer and metal ions collapsing by the external influence (electric signal, temperature change, etc.) (Ergojin, et al. 2010, p. 101). Printers on quasi biological basis[4], allowing considerably to reduce press cost were developed by Kazakhstan scientists. However insufficient financing significantly brakes an embodiment in practice of perspective development within the area of nanotechnological activity.

In the country there are research teams, which carry out researches in nanotechnology field and there are certain achievements. So, universal nanocapsules from phosphatidyl inositol and transdermal forms with their application[5] were created in laboratory of structure and regulation of enzymes of Institute of molecular biology and biochemistry named after M. Aytkhozhin. Nanotechnologies of super crushing for unique devices and for the production of nanodispersed and nanostructural powders were created (mills and mechanical activators surpassing in the characteristics the highest world level)[6].

Large-scale researches in nanotechnology field (in areas of «natural nanomaterials», «technology of extraction of natural carbon nanoparticles», «nanofilms and nanocoverings», «nanotechnologies of technical

[4] http://www.academy.kz/en/useful/item/161 Pavlodar. 17 September. KAZINFORM. Livintsova, V.

[5] http://slanet.kz/Nanotehnologii_Lechebnye_Nanoplastyri/~6919134/~175/.

[6] Nanotechnology «SB: Supercrushing of Bashkirtseva». News of Government Standart, № 5, 2006 – from http://fitomilli.kz/writes/3-publication/23-gosstandart2006-sb.

ceramics on the basis of compound of rare metals», etc.) are carried out at East-Kazakhstan State Technical University (EKSTU), where the mass production of technical ceramics is arranged on the basis of conducted researches (Mutanov, S. 2008, p. 6).

Thus, given examples characterize the condition of domestic market of Kazakhstan having the real scientific and technical potential, certain experience of activity of scientific centers, organizations and universities in nanotechnology field that allows to speak about the prospects of development oriented on world level.

As it is known, the development of nanoindustry in the majority of countries is carried out through the creation of nanoclusters as concrete models of the innovative development, allowing to solve large scientific and technical problems of the industry on the basis of integration of participants during the development and production of nanoproducts. Considering this fact there is obvious need to create corresponding educational cluster as important component of common state innovative system. The success depends on degree of integration during the realization of innovative training of competitive future specialists. So, innovative training of specialists in nanotechnology field taking into account integration processes, conditions and prospects of development of given field, as a whole, must be aimed for corresponding educational cluster's creation in the future.

Innovative training of specialists in nanotechnology field

Innovations in industry, science, education become a priority of development of our state, which has chosen a course on withdrawal from a raw materials economy and transition to science intensive industry (including nanoindustry). Hence a task of ensuring of *innovative nature of education* becomes actual too. The strategy of education is presented in State program of development of education of the Republic of Kazakhstan for 2011–2020 (SPDE RK)[7], where it is planned to raise a share of higher education institutions having created innovative structures, scientific laboratories, science and technology parks, centers (from 14% to 50% in 2020).

[7] State Program of Development of Education of the Republic of Kazakhstan for 2011–2020. – Astana, 2011. – p. 52.

Preparation of specialists in nanotechnology as part of innovative policy is connected with aspiration to increase a contribution of science and technologies in economy development, to provide progressive transformations in the sphere of goods production, to increase competitiveness of national products in world market, to strengthen national security and defense capability of the country, to improve ecological situation.

However, it is necessary to recognize, despite of existence of several universities, where prepare specialists in the nanotechnology field, for the present, in Kazakhstan, there is no enough developed scientific and educational reserve to allow carrying out the preparation according to high international standards. But, as local scientists write, «strategy of development of nanotechnologies can be constructed only on a concrete material» (Ergojin, et al. 2010, p. 13), respectively development of educational sphere in this sector has to be under construction taking into account «a concrete material». Therefore the role of research groups working within *schools of sciences* is steadily increasing.

In this connection in KazNTU named after K. Satpayev fundamental researches dedicated to creation of nanostructured organic polymeric photo cells for transformation of solar energy and nanocomposite materials on the basis of carbon nanotubes are developing within school of sciences of professor Smagulov D. Results of this scientific direction connected with

creation of CVD systems with induction heating for cultivation of multilayered carbon nanotubes (MWCNT);

production of carbon nanotubes and the nanocomposite materials consisting of polymers and carbon nanotubes, which serve for receiving many modern nanostructured functional devices;

receiving of samples of solar batteries of new generation on the basis of organic polymeric photocells.

The projection of these scientific works to education led to pedagogical design of a number of disciplines («Perspective carbon nanomaterials», «Methods of synthesis of carbon nanomaterials», «Modeling of processes of nanomaterials receiving»), including separate modules («Carbon nanotubes», «Polycrystalline diamond (PCD)», «Metalcarbon nanocomposites», «Chemical vapor deposition (CVD technology and equipment»), aimed on formation of concrete professional competences.

Thanks to scientific ensuring of education process oriented on specific objectives of nanoscience and nanoindustry, the KazNTU was determined

by the Ministry of Education and Science of the Republic of Kazakhstan (MES RK) as a head university-coordinator in nanotechnology for Network University of Shanghai Organization of Cooperation (USOC)[8]. Partners of USOC are 60 higher education institutions of China, Russia, Kyrgyzstan, Tajikistan, Uzbekistan. Within USOC joint working training programs and syllabuses are developed and coordinated for specialty «Nanomaterial and nanotechnologies» (for applying in nanoelectronics, chemical and processing industries).

Schools of sciences that are created, mainly, at leading universities of the country serve as the base on which it is possible to carry out innovative training of highly qualified future specialists due to binding of study process to real tasks of industry. Schools of sciences will create the environment in which can be formed *innovative persons*. Such persons are necessary for science-intensive industry, where the most important qualities of specialists are: creativity, deep understanding of economic, production reality. Innovative type of the specialist is characterized by a susceptibility to innovations, ability to fast adaptation in the conditions of changing economic and technical situations.

Specialists in nanotechnology corresponds to category of professional of innovative type, their activity is connected with the highest manifestations of creativity with the fullest scientific knowledge and technologies. The process of training of such specialist differs. For formation of corresponding qualities of specialists of innovative type at all stages of their future innovative activity are required following skills (Makhov, A.):

1) search of new ideas, 2) selection of ideas, 3) analysis of opportunities of production and sale of ideas and production, 4) development of products (design of products and development of technological process), 5) pilot production, 6) checking of market condition, 7) organization of mass production.

The main essence of professional activity of future highly intellectual specialists (postdoc or magister in nanotechnology) is scientific and technical innovation (1 and the 2nd stages), realization of which is possible on the basis of interrelation of intellectual, emotional, strong-willed qualities of the specialist, embodied in intuition, flexibility, independence of thinking and initiative.

[8] http://www.eduweek.ru.

It is possible to master the specified stages of innovative activity in the course of training if *intensive research activity* will be implemented. Intensive research causes chain reaction of ideas, promotes knowledge accuracy, fulfillments of opening. «The intensification of activity is an important form of development of creative abilities of the person leading to creation of innovations because it assumes continuous expansion of a framework of the actions, overcoming of the obstacles arising at the solution of tasks» (Shamelkhanova, N. 2005, p. 70). Thanks to existence of schools of sciences as the basis of scientific and educational infrastructure appears the possibility of real research work meaning intensive works during the solution of specific practical objectives.

Thus, consideration of training of specialists in nanotechnology in parameters of innovations means strengthening of research training component because specialist in nanotechnology is, first of all, the researcher who is using scientific knowledge, research skills in the professional activity. Such specialist has to be able to analyze and generalize world experience, to master scientific and technical achievements according to requirements of modern economy. It is necessary to have the inventive potential and internal need to master innovative processes. Ensuring of innovative nature of training of competitive future specialists leads to achievement of required quality of education and must lean on schools of sciences, existing laboratories with use of unique scientific equipment (devices, installations, measuring complexes and so forth). Use of complicated scientific equipment in the course of research activity of the students and simultaneous development of *technologies of science-oriented training* underlies innovative training. Depending on a type of research activity it is possible to refer to the following technologies of science-oriented training:

– technologies of selection of scientific knowledge (during the development of discipline, modules, tasks);

– technologies of development of theoretical and practical methods of research (mathematical, modeling, special technologies such as technology of mastering of methods of scanning probe microscopy, etc).

So, for students by specialties «Materials science and technology of new materials», «Nanomaterials and nanotechnologies» following technologies of research activity were introduced in educational process:

– development of structure of scientific researches with justification of scientific apparatus,

– organization of independent research work by individual tasks,
– carrying out experimental works with use of modern equipment.

Realization of offered technologies was happened step by step: at first, primary assimilation of a material, then further improvement and on this basis the formation of research and innovative qualities of the students. The concrete innovative projects of university scientists were used for ensuring of science-oriented training during the realization of specified technologies.

However, effective realization of innovative training of future specialists in nanotechnology requires the considering of international experience and active participation in world processes, that makes necessary exit at integration level of training. Following section of article is devoted to the development of scientific and educational integration in given direction of training.

Integration as the main way of realization of innovative training

Based on the above we can emphasize that orientation on interests of industrial and innovative development of the country[9] at the present stage calls the need of search and realization of effective ways of providing of innovative training of specialists for science-intensive industry.

Considering the fact that Kazakhstan's education system has entered into the European educational space, there is inevitable its participation in globalization processes. Therefore in the context of development of innovative training of specialists in nanotechnology field we will substantiate a phenomenon of integration by global tendencies of development of scientific knowledge and activity technologies. It is important to note that nanomaterials and nanotechnologies are a sphere of knowledge not of one country, and the sphere of knowledge of all mankind, that is why integration in area of training of nanotechnology specialists is not only actual, but also inevitable.

Integration as the main way of realization of innovative nature of training is not only caused by requirement to association of efforts in in-

[9] State Program On Forced Industrial And Innovative Development of Kazakhstan Republic for 2010–2014. ASTANA. 19 March, 2010. № 958.

vestigations of the most difficult problems of broad practice. There are general regularities of a development of education, science in the modern world; comparable properties and identical interests of subjects of the integration, allowing to be in relations of integration to form integrity within the general educational space.

Integration can result in new quality of training due to fruitful results of joint cooperation, when the carrying out scientific researches and coordination of theoretical and practical content of education. Innovative nature of the training is provided thanks to research infrastructure of foreign partners, namely the laboratories with the modern equipment, including the equipment necessary for creation and research of nanomaterials and nanostructures: scanning probe microscopes (SPM), installations of spraying, etc. So, as earlier it was already noted, obvious benefits are provided for example due to cooperation with the partners of Russia , which have the experience of educational program creation of RUSNANO for training of methods of nanomaterials receiving.

From researches of foreign and domestic experts it was found out that education systems of world leading countries are actively included in integration processes. But integration in education is wide and not simple notion, which still methodologically isn't developed. In the context of broad adaptation of best practices, integration in international educational space is focused on growing world relationships, new technologies with their developed infrastructure and modern global problems of mankind. It was spoken at a meeting of ministers of the higher education of states-members of G8 in June, 2006. Important step of consolidation of potentials of leading national universities for preparation of highly qualified specialists and specific integration projects is the opening of University of Shanghai Organization of Cooperation (USOC) in 2009.

As a whole real processes of international integration of education systems are realized through numerous international educational projects, adaptation of a number of realities of foreign education in domestic conditions. We think it is a phenomenon of new time, that is in the beginning of the development, and it is irreversible, and, certainly, extends to Kazakhstan. Numerous articles from Internet sites, and also materials of held conferences on the international and republican levels (for example, International scientific and practical conference: «International integration of

educational spaces: priorities and development prospects», organized by the Kazakhstan-American university in Ust-Camenogorsk on October 28–29, 2011) confirm that.

In the majority of economically developed countries the main factors that define leading tendencies of development of nanotechnological preparation are:

– integration and coordination of joint actions of experts;

– expansion of scientific communications at different levels;

– more active involvement of scientists from adjacent fields to participation in discussions, to the developments and joint researches.

Analysis of literature shows that intensive researches connected with creation and development of educational programs with orientation on result are conducted in CIS countries: there are educational programs and joint projects with foreign colleagues, programs of double and joint international diplomas and programs of the international activity, etc.

The particular interest causes the report of Association of the European universities about programs of preparation of PhD in the conditions of transition to knowledge economy, where is emphasized the need of their transformations according to time requirements and creation of preconditions for deepening cooperation in this area. The researches conducted in Kazakhstan on TEMPUS project deserve attention too. They are devoted to definition and introduction of online system on ensuring of quality of educational programs accordingly European standards and Guides to ensuring quality in partner countries.

However integration processes in the sphere of training of specialists for science intensive industry are characterized with high level of uncertainty owing to existing heterogeneity of economic and social development of participants of integration process. It often makes difficult realization of innovative training at integration level without creation of scientific base and formation of relevant structures. In this regard innovative nature of training of specialists in nanotechnology can be provided in the course of concrete joint scientific researches with partners universities, which carried out on the expensive unique equipment taking into account world tendencies of development of nanoindustry. At the heart of integration lies the search the points of international cooperation, where is possible to get advantage and to make final result for scientific and technological breakthrough.

Thus, integration sets reference points on advanced international level of development of nanoindustry and allows to develop the most perspective directions of preparation of domestic specialists.

Proceeding from development of integration there is possible a practical realization of the innovative training that is connected with intensive research activity on the basis of carrying out of joint scientific projects and development of programs integrated into the international educational space. This way of development can lead to improvement of process of preparation of magisters and doctors in the field of nanomaterials and nanotechnologies that will provide competitiveness both educational programs and scientists, and specialists in world market of educational services.

Conclusion

Methodological basics of innovative training of specialists in nanotechnology were considered in the context of the conditions and prospects of development of science intensive branch, ensuring innovative nature of training, and also integration interaction of partners universities. As a whole theoretical substantiation of the content of training of future specialists in nanotechnology is aimed at creation of corresponding educational cluster as important component of common state innovative system.

The state of domestic market of Kazakhstan is characterized with the examples of nanotechnological development given in the article. Existence of scientific and technical potential, certain experience of activity of scientific centers, organizations and universities in nanotechnological sphere allows to speak about development prospects (including educational sector), oriented on world level.

Innovative training is connected with intensive research activity, which is realized during the creation and the development of schools of sciences.

Integrative interaction in nanotechnology field will allow to realize effectively innovative training on the basis of international transfer of knowledge and introduction of new technologies of the organization of research activity and training methods.

Dear colleagues!
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МЕТОДОЛОГИЧЕСКИЕ ОСНОВЫ ИННОВАЦИОННОЙ ПОДГОТОВКИ СПЕЦИАЛИСТОВ В ОБЛАСТИ НАНОТЕХНОЛОГИЙ

Аннотация к статье (авторское резюме, реферат):

Для осуществления инновационной системы подготовки высококвалифицированных специалистов для экономики Казахстана планируется создание и развитие нанотехнологического рынка в стране; преподавание инновационной инженирии в сочетании с интенсивными научными исследованиями, интеграция подготавливаемых специалистов в современные технологии и в науку на международном уровне. Методологические аспекты имеют специфическую направленность на подготовку конкурентоспособных специалистов именно в области нанотехнологий. Раскрываются методологические подходы инновационной подготовки специалистов для промышленности высоких технологий, которые выполнялись по грантам Министерства науки и образования Республики Казахстан.

Ключевые слова: Nanotechnology, innovative training of specialists, schools of sciences, intensive research activity, science-oriented technologies, integration.

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