FEATURES OF STUDYING A NANOPHYSICS COURSE IN HIGHER EDUCATIONAL INSTITUTIONS

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Аннотация. *Бизга маълумки, нанотехнологиялар бўйича мутахассислар тайёрлаш вазифаси бевосита олий таълим билан боғлиқ. Дунёнинг бир қатор етакчи олий ўқув юртларида нанотехнологияга йўналтирилган кафедралар очилган, тегишли ўқув дастурлари яратилмоқда, ўқитувчилар таркиби, жумладан, турли билим соҳаларининг етакчи олимлари шакллантирилмоқда. Шунингдек, нанотехнологиянинг инсон фаолиятининг барча соҳаларига кириб боришини эътиборга оладиган бўлсак, мутахассисларни тайёрлаш қамровининг кенглигини кўрамиз. Маълумки, олий ўқув юртлари, жумладан, институт ва университетлар, коллеж ва техникумлар ва лицейлар замонавий билимларга эга, нанотехнологиялар, хусусан, нанофизика бўйича мураккаб илмий-техникавий муаммоларни ҳал қила оладиган янги авлоднинг юқори малакали мутахассисларини тайёрлашда муҳим ўрин тутади. Ушбу мақолада биз янги ва тез ривожланаётган нанотехнология соҳасидаги замонавий илмий ютуқлар муаммолари ҳамда юқоридаги муассасалар дастурига махсус фан киритилган нанотехнологияга оид билимларни ўқитиш масалалари кўриб чиқилди. Таълимнинг умумий, ўрта ва ҳатто бошлангич босқичи ўқувчиларини замонавий билимларга эга, мураккаб илмий, технологик ва инновацион муаммоларни ҳал этишга қодир бўлган янги авлоднинг юқори малакали мутахассисларини тайёрлашга касбий йўналтириш – яқин келажакда ҳал қилиниши керак бўлган мураккаб вазифа эканлиги кўрсатилган.*

Калит сўзлар: *нанотехнология, нанотаълим, кадрлар компоненти, минтақавий нанотехнологиялар тармоги, иқтисодий ривожланиш.*

Аннотация. *Как известно, задача подготовки специалистов в области нанотехнологий напрямую связана с высшим образованием. В ряде ведущих высших учебных заведений мира открыты кафедры, ориентированные на нанотехнологии, создаются соответствующие образовательные программы, формируется профессорско-преподавательский состав, включающий ведущих ученых различных областей знаний. Также, если принять во внимание проникновение нанотехнологий во все сферы человеческой деятельности, мы увидим широту сферы подготовки специалистов. Известно, что высшие учебные заведения, в том числе институты и университеты, колледжи и техникумы и лицеи, занимают важное место в подготовке высококвалифицированных специалистов нового поколения, обладающих современными знаниями и способных решать сложные научно-технические задачи в области нанотехнологий. в частности, нанофизика. В данной статье мы рассмотрели проблемы современных научных достижений в области новых и быстро развивающихся*

нанотехнологий, а также вопросы преподавания знаний о нанотехнологиях, что является специальным предметом, включенным в программу вышеперечисленных учреждений. Показано, что профессиональная подготовка учащихся общего, среднего и даже начального уровня образования для подготовки высококвалифицированных специалистов нового поколения, обладающих современными знаниями и способных решать сложные научные, технологические и инновационные задачи, является сложной задачей, которую необходимо решить. решена в ближайшее время.

Ключевые слова: *нанотехнологии, нанообразование, кадровая составляющая, региональная нанотехнологическая сеть, экономическое развитие.*

Abstract. *As we know, the task of training specialists for nanotechnology directly relates to higher education. A number of leading universities have already opened departments with a nanotechnology focus, corresponding educational programs are being created, and a staff of teachers is being formed, including leading scientists from various fields of knowledge. One should also keep in mind the predicted entrance of nanotechnology into literally all sectors of human activity, which determines, so to speak, the breadth of coverage in the training of specialists. It is clear from here, what is the complexity and what is the novelty of the tasks facing educational institutions. It is well known that higher educational institutions, including institutes and universities, colleges and technical schools. and lyceums play a key role in training highly qualified specialists of the new generation who have modern knowledge and are able to solve complex scientific and technical problems in nanotechnology, in particular nanophysics. This paper examines the issues of scientific achievements in the field of nanotechnology, which is developing new and fast, as well as the problems of teaching knowledge about nanotechnology as a special subject included in the program of the above institutions. Professional orientation of students of general secondary, secondary and even primary levels of education in the preparation of highly qualified specialists of the new generation, possessing modern knowledge and capable of solving complex scientific, technological and innovative problems, is a complex task that must be solved in the near future. as possible.*

Key words: *nanotechnology, nanoeducation, specialist component, regional nanotechnology network, economic development.*

Introduction. The current status of the domestic economy brings to the fore the need for its modernization and transition to an innovative path of development. It should be stated that the basis for the growth and development of the economy and the transition to a new technological structure is the use of the latest achievements of science - nanotechnology. One of the conditions for the development and implementation of nanophysics is the training of appropriate specialist in the field of nanoeducation. One of the prerequisites for the economic growth of any country is the specialist component. At this stage of development of the domestic nanotechnology sector, there is an acute shortage of human resources. One of the possible options for overcoming the shortage of specialist in the field of nanophysics is the creation of a system of education and training of highly professional specialist for their effective development [1].

Obviously, the task of training specialists for nanotechnology directly relates to higher education. A number of leading high educational organizations have already opened departments with a nanotechnology focus, corresponding educational

programs are being created, and a staff of teachers is being formed, including leading scientists from various fields of knowledge. Over time, under the pressure of practical needs, the higher education system in relation to nanotechnology will grow, take shape and take on a specific appearance, because specialist decides everything. In the case of training specialist to work in the field of nanotechnology, a fundamental feature is the training of specialists with a broad view of the world, professing the idea of the unity of the world, and deeply understanding the atomic-molecular structure of the world. In addition, conscious manipulation of atoms and molecules is impossible without knowledge of quantum mechanics. One should also keep in mind the predicted penetration of nanotechnology into literally all sectors of human activity, which determines, so to speak, the breadth of coverage in the training of specialists. From here it is clear what is the complexity and what is the novelty of the tasks facing educational institutions [2-6].

By analyzing the experience of implementing nanophysics in economically and technologically developed countries, we believe that the formation of human resources in the field of nanophysics should occur through the creation of a system of interdisciplinary education. Such a system should cover both higher school, postgraduate and doctoral studies, and general secondary education. A necessary aspect of it may be the creation and study of special interdisciplinary courses, holding conferences and summer schools in the field of nanophysics [2]. When forming the specialist component of the nanotechnology sector, cooperation between higher educational institutions, general education institutions, research institutions, and industrial enterprises producing nanotechnology products is important.

Such complex, knowledge-intensive technologies as nanotechnology require appropriate specialists for their implementation: scientists, designers, engineers and etc. It would be possible to bring together the relevant narrow specialists, create some kind of coordinating body, and the work would begin. Actually, this is what is done at the initial stage. But the complexity and scale of the project do not allow us to limit ourselves to this. It is obvious that people need to be specially trained to work in the field of nanophysics. They have long been able to train specialized specialists in certain fields of knowledge. But in the case of training specialist to work in the field of nanophysics, a fundamental feature is the training of specialists with a broad view of the world, professing the idea of the unity of the world, and deeply understanding the atomic-molecular structure of the world. In addition, conscious manipulation of atoms and molecules is impossible without knowledge of quantum mechanics. One should also keep in mind the predicted penetration of nanophysics into literally all branches of human activity, which determines, so to speak, the breadth of coverage in the training of specialists. From here it is clear what is the complexity and what is the novelty of the tasks facing educational institutions. Obviously, the task of training specialists for nanophysics directly relates to higher education. A number of leading universities have already opened departments with a nanotechnology focus, corresponding educational programs are being created, and a staff of teachers is being formed, including leading scientists from various fields of knowledge. Over time, under the pressure of practical needs, the higher education system in relation to nanotechnology will grow, take shape and take on a specific appearance, because specialist decides everything.

1. Current status of the nanophysics science.

It is obvious that industrial enterprises can develop thanks to the discoveries and innovations of research institutions. In turn, educational institutions should actively cooperate with industrial enterprises, and also be purposefully funded by the state in order to train highly professional specialist capable of meeting the requirements of modern nanoindustry and the prospects for its development . This program provides: to achieve a fundamental understanding by students of the Faculty of Physics and Mathematics of the achievements of modern science, which allows for control and manipulation of atoms and objects within the nanometric scale; provide grants to individual students; ensure the formation of a regional educational nanotechnology network, increase awareness and competitiveness of high-tech industries, ensure effective education and training of research specialist [7].

It is known that not all basic methods for studying nanoobjects - electron microscope, atomic force microscope, scanning tunneling microscope, nanothermometer, nanobalances, nanoindenter, etc., which can be useful for the further development of nanophysics, are available in every university. Despite this, there is a prospect for the study and implementation of nanophysics, and first of all it is based on the unification of university, industry and academic science, and international scientific cooperation.

In our opinion, the quality of teaching nanophysics in a physics course is the basis of scientific and technological progress of each educational institution, in particular the university. The key to improving the quality of teaching is to increase the level of human capital of each teacher. The individual human capital of university graduates and teachers is their accumulated certain stock of health, knowledge, skills, abilities, creative motivations and cultural traditions, established educational and scientific laboratories, developed research projects and teaching aids that are used in the process of managing student knowledge. We believe that one of the priority areas of work for educational institutions should be to involve students and teachers in innovative projects in the field of nanophysics and the widespread popularization of nanotechnological knowledge. An analysis of the topics of materials presented by scientists for various scientific journals shows that they really analyze the most important issues in the teaching methods of modern physics and, what is especially important, almost a third of the messages relate to the analysis of the possibilities of considering issues related to nanophysics in school and university physics courses. methods for studying nanoobjects and methods for presenting these issues. These are precisely the breakthrough areas that are actively developed and used by the most technologically advanced countries in the world. Perhaps, thanks to precisely such scientific research in nanophysics, which is widely promoted abroad, and children there are introduced to it from early childhood, it will come to our schools and universities.

2. Elementary concepts of the nanophysics course

The first position of the molecular kinetic theory states: “all bodies (substances) consist of an extremely large number of tiny particles - molecules (or atoms).” This became finally clear about a hundred years ago. But only now does this position acquire practical meaning: if everything is made of molecules and atoms, then why not do what we need by directly connecting molecules and atoms in a certain order. This is how

houses are built - brick by brick, and in the end you get a building. Until now, when making something, people thought little about atoms and molecules; macro-objects were taken - ore, wood, other raw materials - and processed using appropriate technologies, cutting off the excess, exposing the macro-object to any influences. Now a completely new concept is being proposed: we will make what we need directly from those very small particles from which everything consists. This was first stated by R. Feynman about fifty years ago in the following words: "If we learn to manipulate atoms, we can do anything." The concept looks extremely simple, but how to implement it? After all, the sizes of atoms are 0.10.3 nm, respectively, the sizes of molecules are slightly larger, about 1 nanometer (a nanometer is a characteristic molecular size). Such objects are not visible in conventional microscopes [4-7]. However, modern electron microscopes, tunnel scanning microscopes and atomic force microscopes, which appeared about 20 years ago, made it possible to "see" individual molecules and atoms. And not only to see, but also to move individual atoms and molecules from place to place. Thus, the possibility of manipulating individual atoms and molecules, which is the cornerstone of nanobjects, was fundamentally demonstrated. It should be remembered that technically manipulating individual atoms and molecules is, of course, extremely difficult and nanofabrication is unlikely to be cheap.

Naturally, the question arises: why is it necessary to construct nanosized objects in this way? The point here is not only about the miniaturization of something, and this trend can be seen not only in electronics. The main thing is that nanoobjects must have special properties and characteristics that are impossible among macro-objects. This happens because the behavior of atoms and molecules, their interaction, is governed by the laws of quantum mechanics, the paradoxical nature of which and unusualness for everyday perception are undeniable. There is no point in constructing any ordinary macro-objects from individual atoms and molecules - this is much easier to do within the framework of already known technologies. But the prospect of creating nanodevices, nanomachines with fundamentally new unusual characteristics is very tempting. And this is not a matter of some distant or even near future, this is already the current reality, when almost every day there are reports of new nanoobjects, nanomaterials, nanomachines with amazing properties [8, 9].

3. Issues and prospects for training qualified specialist in nanophysics.

One of the main directions of university education reform is the introduction of training in nanophysics. The purpose of this reorganization is to improve the level of education of the younger generation, which no longer meets the new challenges. Much is being done to increase university students' interest in science and technology, which has been declining over the years. It is believed that the entire education system should be built around nanophysics. Since they combine physics, chemistry and biology, etc., these disciplines must be taught not separately, but in combination. To improve the qualifications and training of teachers in this new direction, many seminars and courses are held at a number of universities. Distance programs for advanced training are being created, which are focused on education, as well as on promoting the ideas of nanophysics for all segments of society. The teaching of the fundamentals of

nanophysics is already provided for in educational programs in the perspective documents of many countries, which is due to the need for the student to choose a profession and subsequently train him at a university, with basic training corresponding to the modern level of development of science and industry [10].

We are convinced that the key to the development of the country is in school, since not only future workers, engineers, doctors, builders, and scientists study and are educated there. Therefore, they, like all school graduates, from childhood should be familiar with modern achievements of science, with the basics of nanoscience, because This is the area of knowledge and its practical applications that will ensure the country's transition to a new technological structure, towards which all developed countries of the world stand. In general, schools and universities face big challenges. Teachers of schools and universities in their educational work with students and schoolchildren must constantly focus their attention on this thesis. A school teacher and a university teacher are the main links in the educational process; today we work with students, and tomorrow they are our people, who have or, conversely, do not have an idea about modern scientific achievements and the possibility of their implementation in modern production and everyday life, and , which means thinking and acting either according to the criteria of yesterday, or according to the requests, requirements and opportunities of the new time. The inclusion of nanophysics in the curriculum of physics, chemistry, biology, and computer science today will contribute to the development of the regions and the country as a whole, and this will be realized as a result of the creation and active functioning of the nanotechnology program of the regions and the construction of a regional nanotechnology network.

Currently, many scientific institutions around the world are analyzing the problem of training in the field of nanotechnology. This is largely due to the fact that nanotechnology is a relatively new scientific field that is part of many other disciplines. In the education system abroad, the approach to the professional training of scientific specialist in many areas is changing, interdisciplinary connections are emerging, and a significant number of specialized courses and electronic training courses on nanotechnology are appearing. The training of specialists in the field of nanotechnology in developed countries has been going on for a long time. For example, in countries where work in the field of nanophysics has been declared the highest priority, educational nanocenters have been created, covered by a unified information exchange network with universities connected to it; private institutes and government laboratories. Education and propaganda in the field of nanophysics in these countries affects all levels of society - from junior levels of education to retraining of specialist, including universities, colleges, etc. [10].

We may distinguish two areas of training in the field of nanophysics, which differ significantly from each other. Most European countries have narrowly focused educational programs on nanomaterials and nanotechnologies. In other countries, the prevailing opinion at universities is that this is part of a more general problem of materials science and, therefore, it is necessary to train fundamental specialists with a good knowledge of chemistry, physics, and mechanics of materials. For the rapid and successful development of nanophysics, it is necessary to develop training courses and

programs that will professionally prepare a new generation of researchers and workers capable of working in this new, complex field of science and technology. The need for changes in the education system was considered in strategic government documents related to the development of nanophysics in the world's leading countries. The ongoing changes in the education system primarily affect higher education, the training of master's and doctoral students, as indicated in the national strategies of these countries. Considerable attention is paid to the need to organize training courses and train scientists and researchers in specialized scientific centers, both in the countries themselves and in departments abroad. Due to the dynamically growing demand for specialists in nanotechnology, many scientists engaged in fundamental research in this field also participate in didactic activities, conduct training courses, various seminars and conferences. Basic issues related to nanotechnology are included or have already been included in the curricula of all levels of education, starting from preschool. Thus, we can say that the training of specialists in the field of nanoscience and nanotechnology abroad is carried out at special courses, in colleges, universities, private institutes, in research centers and government laboratories of both their own countries and partner countries; Special educational projects for the Internet are also being developed.

As already noted above, training specialists in the field of nanophysics requires retraining of teaching staff and a more complex organization of the educational process. The need to accelerate specialist training in this area is obvious, but the existing licensing system hinders the opportunity to obtain education in the field of nanophysics, primarily for certified specialists and students of non-core natural science and engineering universities; Obviously, in order to expand the list of licensed specialties in the field of nanotechnology, it is necessary to train high-level teachers, attract highly qualified specialists to teach, and create appropriate departments. The training of scientific, engineering and worker specialist in the field of nanotechnology requires the development of new educational programs: courses of lectures and textbooks for specialists and for retraining teaching staff; programs for students (starting from the third year); electives for schoolchildren and technical school students.

It can be assumed that in the near future there will be an increase in the number of universities, faculties, and departments offering programs in the field of nanophysics. Training in nanosciences involves a two-level training system (bachelor's degree - 4 years, master's degree - 2 years). Specialists are trained in the same areas as in other universities: nanochemistry, nanophysics, nanobiology, synthesis of nanomaterials, optical spectroscopy, mathematical modeling, etc. However, the marketing and innovation direction in the field of training specialists in nanotechnology is practically not represented. It is especially necessary to train specialists who simultaneously have a good knowledge of mathematics, physics, chemistry, mechanics, and biology. Only an interdisciplinary educational program can provide a nanotechnological breakthrough.

Conclusions. Thus, the need to create a modern system for training professional specialist for the nanoindustry is one of the main conditions contributing to the development of the economy and society as a whole. Increasing the competitiveness of

specialists and, as a result, the products of knowledge-intensive enterprises in the region is possible through the development and implementation of the Nanoindustry Development Program through the joint efforts of enterprises, universities, specialized industry and academic institutes, as well as with the support of the state.

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