Features of training specialists for responsibility centers of the project direction “Proryv”

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Abstract. National Research Nuclear University “MEPhI” (NRNU MEPhI) is the leading university of the consortium of reference universities of the State Atomic Energy Corporation Rosatom (ROSATOM), a regular supplier of young specialists of the highest level. Since 2014 NRNU MEPhI has been training graduates for responsibility centers of the project direction “Proryv”. University responds quickly to staffing challenges, and provides the project "Proryv" the personnel with relevant unique competencies. These competencies include the ability to apply the knowledge gained to develop a new technological platform for nuclear power with the involvement of uranium-238 and spent nuclear fuel reprocessing products in the fuel cycle. Obtaining such unique knowledge is impossible without the use of external resources, namely, the involvement of leading scientists and practitioners of ROSATOM for conducting classes with students, organizing practices in scientific centers and at nuclear fuel cycle enterprises. The article discusses the features of the organization of the educational process in this area.

1. Introduction

Any educational program is based on the Federal Law “Concerning education in the Russian Federation” (No. 273 - FL dated December 29, 2012) with subsequent changes and additions. It is the foundation of the educational system of the state, establishes basic principles and regulates educational relations. The next step in the hierarchy of building the basic educational program is the orders for the approval of federal state educational standards by levels of education and areas of training. The direction of training for masters on 14.04.02 "Nuclear Physics and Technologies" is regulated by the order of the Ministry of Education and Science of the Russian Federation No. 152 of February 28, 2018. Some higher education institutions, in accordance with article 2, clause 7 and article 11 clause 10 of the Federal Law are given the right to develop and approve educational standards independently. At the same time, the results of mastering educational programs cannot be lower than federal standards. The standard in the area of training on 14.04.02 was approved by the academic council of NRNU MEPhI on May 31, 2018. It is a set of requirements that are mandatory in the implementation of educational programs in this area of training by all structural divisions of NRNU MEPhI.

In accordance with the NRNU MEPhI educational standard, the competence model of a graduate is highlighted as a mandatory component of educational programs, which should be developed taking into account the request of key employers. The competency model of a graduate is a combination of social and personal, general professional and special competencies that allow a graduate to effectively solve...
professional problems. Core competencies such as universal, general professional and professional are established by the educational standard. The competencies corresponding to the profile of the educational program are established by the department that implements it. On the basis of the educational standard and competence model, a working curriculum of the educational program and educational and methodological kits for disciplines are developed.

2. Profiles of training graduates within the educational program
The main profile of the educational program of the department “Closed nuclear fuel cycle technologies” since 2014 was originally declared as “Nuclear power technologies of new generation”. The purpose of the training is to select talented young people and organize targeted training for the strategic project of ROSATOM - the project direction “Proryv”. The purpose of activities under the project direction “Proryv” is the creation of nuclear-energy complexes that include fast neutron nuclear power plants with lead and sodium coolant, spent nuclear fuel reprocessing plant and fuel re-fabrication plant, preparation of all types of radioactive waste to the final disposal into geological formations [1-2]. Head of the Master’s program - head of the department “Closed nuclear fuel cycle technologies”, special representative of ROSATOM for international and scientific projects, head of the project direction “Proryv”, doctor of technical sciences, professor Vyacheslav Pershukov. The educational program combines the fundamental training of NRNU MEPhI and special courses taught by leading expert practitioners and scientists of ROSATOM [3-4].

The following courses are implemented in the education program: the core courses of NRNU MEPhI; the special courses corresponding to the education program specialization; advanced courses in the closed nuclear fuel cycle (CNFC) technologies. The core courses are the following: technical English, special chapters of advanced mathematics, nuclear physics, scientific knowledge methodology. The special courses corresponding to the educational program specialization: neutron transport theory, scientific basis of nuclear power, radiochemistry, engineering analysis of nuclear reactors. Among the special courses in CNFC technologies, there are: neutronics of fast neutron reactor cores and the closed nuclear fuel cycle, spent nuclear fuel reprocessing, fast nuclear reactors, nuclear fuel cycle economics.

An example is the block "Radiochemistry and the nuclear fuel cycle", which lasts three academic semesters with increasing volume, as shown in figure 1. The course “Radiochemistry” is given during the first semester in the D. Mendeleev University of Chemical Technology of Russia (MUCTR). It is the levelling course for the magisters entered from different universities. The main purposes of the course are learning of the book knowledge by students in the area of the general and applied radiochemistry, transfer of skills of working with radioactive substances to the students. The knowledges

![Figure 1. The structure of the block of disciplines "Radiochemistry and the nuclear fuel cycle".](image-url)
gained by the students during learning of the course “Radiochemistry” are demanded further in the course “Radiochemistry (special chapters) which is also given on the base of the MUCTR in the quantity of five class-room based hours per week including laboratory works. The course is aimed at learning of the theoretical basis of radionuclide concentration, extraction and separation procedures used both for environmental medium analysis and for analysis of process solutions and their products. At the third semester, the block is already given in two disciplines. The MUCTR gives the course “Radioactive waste handling technologies”. Its main objective is to learn the basic principles of radioactive waste handling, production processes of radioactive waste immobilization, disposal methods. The course “Spent nuclear fuel reprocessing” is given by the leading specialists of JSC “High-tech research institute of inorganic materials named after academician A.A. Bochvar” (JSC VNIINM) on the basis of this institution. The course objectives includes: learning of industrial implemented and advanced technologies of spent nuclear fuel (SNF) reprocessing; reprocessing characteristics of SNF produced by fast neutron reactors and thermal neutron reactors; insight into requirements to the final products of SNF reprocessing.

The skills learned during the first two semesters are developed during learning the course “Technology and equipment of the nuclear fuel cycle enterprises”. The students leave for Seversk CATU where they receive theoretical training six hours in a day during the first week in the Seversk Technological Institute of NRNU MEPhI. The second week is devoted to the introduction practical training in “Siberian Integrated Chemical Plant” JSC including visiting the radiochemical plant, the sublimation plant, the isotope separation plant, the industrial reactor and the chemical and metallurgical plant. Just at the site of the “Siberian Integrated Chemical Plant” JSC, the pilot and demonstration power supply package is under building consisting of the fast neutron reactor plant “BREST-OD-300”. The students may have a look at the construction progress and, currently, at the manufacturing technology of fuel and fuel assembly with nitride fuel.

In 2017, it was decided to distinguish in the educational program the profile "Engineering computer modeling in the nuclear industry". Head of the master's program Aleksey Soldatov, doctor of physical and mathematical sciences, head of the department of “Computer Engineering Modeling”. The goal is to train specialists in the field of application and development of digital economy tools, namely, the application of well-known packages of full-scale computer engineering modeling to the development and engineering design of various products and objects, as well as the development of new software. The obtained knowledge is used by graduates to perform a computational analysis of the integrity and reliability of power equipment of nuclear installations. Main customers - Keldysh Institute of Applied Mathematics, N.A. Dollezhal Research and Development Institute of Power Engineering, NRC “Kurchatov Institute”.

Since 2019 in NRNU “MEPhI” began the training of graduates under profile “Modern computational methods and software systems for safety analysis of promising nuclear power plant projects”. The purpose of training in this area - is to prepare professionals for responsibility centers of the project direction “Proryv” with the skills to work with domestic new generation codes used to develop and substantiate the safety of nuclear facilities of a new technological platform of nuclear energy [5]. The training profile director is doctor of physical and mathematical sciences, academician of RAS, scientific director of Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE RAS) Bolshov Leonid Aleksandrovich.

The profile is implemented in a network form. Part of the courses are conducted based on IBRAE RAS, where students receive special knowledge on the following topics:

- modern mathematical models, effective computational methods, programming technologies and approaches to collective software development;
- development of new generation application software for the substantiate of nuclear power plant safety;
- computational modeling of various modes of nuclear power plant operation.

During the educational process, students master the thermohydraulic HYDRA-IBRAE/LM code, the integral code for nuclear power plant safety justification EUCLID, the fuel rods behavior code BERKUT, and the BPSD code for calculating burnup and residual energy release.
3. Experience in implementing an educational program

Starting from 2014, the enrollment was 10 - 13 people, graduation 7 - 10 masters. If for the first time the main recruitment was made by bachelors from NRNU MEPhI and specialists working at the enterprises of the ROSATOM, then as the educational program developed, the geography of the enrollment has changed somewhat. Bachelors from NRNU MEPhI make up no more than half of the group, and the rest of the students are bachelors from other universities. The enrollment statistics are shown in figure 2.

Figure 2. Enrollment statistics for the educational program.
The decoding of the names of universities not mentioned in the article is as follows:

- BMSTU – Bauman Moscow State Technical University;
- CFUV - V.I. Vernadsky Crimean Federal University;
- INRTU - Irkutsk National Research Technical University;
- KFU - Kazan Federal University;
- MISIS - National University of Science and Technology MISIS;
- MPEI - National Research University "Moscow Power Engineering Institute";
- MSU - Lomonosov Moscow State University;
- NNSTU - Nizhny Novgorod State Technical University n.a. R.E. Alekseev;
- PNRPU - Perm National Research Polytechnic University;
- RUT - Russian University of Transport;
- SPbPU - Peter the Great St.Petersburg Polytechnic University;
- SSAU - Samara National Research University;
- TPU - Tomsk Polytechnic University;
- TSNUK - Taras Shevchenko National University of Kyiv;
- TSU - Tula State University;
- UrFU - Ural Federal University.

Figure 3. Statistics performance of graduation qualification works.
A more interesting issue is the distribution of students according to the places of their graduation qualification work. Statistical data are shown in figure 3. It can be seen that if in the first year of the implementation of the educational program all work was carried out in the interests of the project direction “Proryv” [6-7], then starting from the second year, students began to be distributed more diversely. The decoding of the names of universities not mentioned in the article is as follows:

- FRCCP RAS – N.N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences;
- GOSNIIAS - Federal State Unitary Enterprise State Scientific Research Institute For Aviation Systems;
- GSPI - State Specialized Design Institute, JSC;
- IKI - Space Research Institute of the Russian Academy of Sciences;
- IPPE - State Scientific Center of the Russian Federation, Institute for Physics and Power Engineering, A.I. Leypunsky;
- NRCKI - National Research Center “Kurchatov Institute»;
- VNIIHT - All-Russian Research Institute for Chemical Technology;
- VNIINM - A.A. Bochvar High-Technology Scientific Research Institute for Inorganic Materials.

As can be seen from figure 3, the circle of graduates customers is much wider than it was initially assumed. Each customer is committed to ensuring that the special competence of students received not only during the passage of the practice and performance of graduation qualification work, but also in the development of academic disciplines. Over the years of implementation, the educational program has confirmed the ability to combine the various requirements of employers within the framework of the principle of individual student learning paths.

4. Conclusion
Since 2014, NRNU MEPhI has been training graduates for responsibility centers of the project direction "Proryv". The basic principle of multidisciplinarity and wide involvement of external resources made it possible, within the framework of a single educational program, to implement various training profiles in the interests of employers.

The experience of implementing the program can be useful in organizing training for the project direction "Proryv" both in other universities and in creating centers of competence.

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