

Innovative Education Programs in the Fields of Chemistry and Sustainable Development at D. Mendeleev University of Chemical Technology of Russia

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Abstracts

Ideas of sustainable development spreading through the educational system form the framework of innovative programs. The problems of sustainable development are recognized as a constituent of professional training in many areas. It is shown with the example of D. Mendeleev University of Chemical Technology of Russia that the innovative potential of sustainable development becomes the driving force of modern education. The principles underlying education for sustainable development include understanding of interdisciplinary relations and responsibility for social consequences of application of knowledge.

*In the geological history of the biosphere,
a great future is opened to Man if he realizes it
and does not direct his mind and work to self-
destruction.*

V. I. Vernadsky,

“A Few Words about the Noosphere”, 1944

(quoted from V. Vernadsky, *Geochemistry and the Biosphere*, Synergetic Press, Santa Fe, 2007).

Education is a fascinating field of human activity, which enables transfer of knowledge between generations, creating the unique non-genetic channel of propagation of hereditary information (in the form of educational systems). Developing this analogy, it is possible to note the remarkable stability (persistence) of educational paradigms: some of them remain alive for several centuries [1]. Meanwhile, the world is changing, and mankind is one of the driving forces in this process, at the same time being affected by the changes [2]. In the autumn of 1996, during his last speech at the D. Mendeleev University

of Chemical Technology of Russia, Valentin Afanasievich Koptuyug, arguing about the urgency of cardinal reformation of science and education, particularly accented the following trends [3]:

1. Basic understanding of interconnection between all aspects of human life and anthropogenic processes and environmental conditions should be founded already at the stage of general education, as well as the fundamentals of systematic understanding of the character of the current civilisational crisis.

2. At the stage of higher professional education the above course should gain deeper de-

velopment with concomitant specification of primary large-scale challenges for each particular academic or applied discipline.

3. Education (especially the higher one) and science are two stages of taking knowledge, and further efforts must be applied to their integration.

4. Science should provide deeper understanding of global challenges to mankind and finding the keys for their solutions on multidisciplinary basis.

5. With understanding of the role of the cultural factor in the realization of the concept of sustainable development, the multidisciplinary character of education should be enforced in parallel with enhancement of the humanitarian aspects.

A prominent scientist and research administrator, Russian patriot, V. A. Koptug believed that the ideas of sustainable development would spread through the educational system and become a decisive factor in Russia of 21 century. Acting as the head of the scientific section of Russian delegation at the historical United Nations Conference on Environment and Development (Rio de Janeiro, 1992), during the conference he repeatedly spoke on diverse subjects, came forward with suggestions and numerous editorial corrections to the adopted documents [4]. The key final document of the conference was Agenda 21, its Chapter 36 being devoted to education for sustainable development. This contribution presents the results achieved during the last fifteen years at the Mendeleev University, which became, for a number of external and internal reasons, *sui generis* point of growth of this school in the country.

Following the recommendations of Agenda 21, the chair of problems of sustainable development was organized at D. Mendeleev University of Chemical Technology of Russia in 1995, the chair providing the teaching of a new course "Problems of sustainable development" for students of all departments of the university. It became the first chair of this kind in Russia and one of the first in the world. Its basic tasks were the propagation of the idea of sustainable development, working-out curricula and programs in this field. The principles underlying education for sustainable development include systems thinking, continuous ed-

ucation, and acquisition of fundamental knowledge in natural sciences, understanding of interdisciplinary relations, practical research skills, and personal responsibility for social consequences of application of knowledge.

According to recommendations of Chapter 36 of Agenda 21, the study of the problems of sustainable development should be a constituent of professional training or can be organized as an individual general course. The creation of the course "Problems of sustainable development" at D. Mendeleev UCTR followed the second approach. This course is among the most contemporary educational courses and suggests cross-disciplinary and systematic approach to the study of the major problems of interaction between mankind and environment from the viewpoint of sustainable development.

In this course the students acquire complex knowledge including basic concepts and principles of the philosophy of sustainable development; introduction in system dynamics; the idea of stability and instability of dynamic systems; understanding of the biosphere as a dynamic system; fundamental facts about the Earth biosphere and its physical chemical characteristics; basic understanding of global challenges, resources and development, anthropogenic impact and environmental quality management; quantitative and qualitative criteria of sustainable development; examples of modeling of evolution of the society; economic, social, political and ethical problems of sustainable development; the problems of decision making.

For elaboration of practical skills in collective decision making, the program of the course includes two simulation games. They are adapted Russian versions of the games developed by well-known American researcher D. Meadows and colleagues: "Fishbanks" – management of renewable resources and "Strategema" – a network game based on the well-known World3 model elaborated on preparation of the report "The Limits to Growth" for the Rome's Club. It should be noted that as early as in 1987, by recommendation of the Corresponding Member of AS USSR G. A. Yagodin, who is the patriarch of ecological education in USSR and the founder of the first Soviet chair in industrial ecology (1983), professor D. Meadows was awarded Honoris Causa Doctorate at D. Mendeleev UCTR.

In the year 2000 the chair of problems of sustainable development launched the general course "Analysis and Management of Industrial Hazards", elaborating and extending the subjects of the discipline "Problems of Sustainable Development". This course is based on ideas of another outstanding Mendeleev University graduate – Academician V. A. Legasov. In the same 2000, Institute of Chemistry and the Problems of Sustainable Development (ICPSD) was organized as the department of the Mendeleev University. Now it comprises the chairs of the problems of sustainable development (headed by Corresponding Member of RAS N. P. Tarasova), sociology (headed by professor S. A. Gubina), life safety (headed by Professor L. K. Marinina), national policy of natural resource management and environmental safety (headed by Professor A. G. Ishkov), Higher Chemical College of Russian Academy of Sciences (research supervisor Academician O. M. Nefedov), Higher College for Rational Use of Natural Resources (research supervisor Academician N. P. Laverov), Higher School of Environmental Sciences (research supervisor Corresponding Member of RAS G. A. Yagodin). More than 400 students are trained at the institute. The best of them are awarded Academician V. A. Koptuyug scholarship established by Mendeleev UCTR academic council in the year 2000.

The integration of graduation chairs and higher colleges of different courses and training specializations enables practical realization of the idea of cross-disciplinary education for sustainable development. The chairs and colleges cooperate in development and modification of curricula and programs, including the training in decision making with consideration of short- and long-term consequences for economy and environment of Russia and the whole world community. Besides the natural science subjects, curricula and programs of all training levels of ICPSD graduates include the problems of population dynamics, ethics, economy, civil rights, other social economy problems. The skills in strategic analysis are trained with the use of ecology-demography-economy simulation model (EDEM) developed for ICPSD by researchers of Dorodnitsyn Computing Centre of the Russian Academy of Sciences headed by Corresponding Member of RAS Yu. N. Pavlovsky.

The students of the chairs and colleges of the Institute of Chemistry and the Problems of Sustainable Development are trained by Mendeleev UCTR staff, researchers from RAS institutes and leading experts from other organizations.

In 2000 a group of Mendeleev UCTR teachers was awarded the Prize of President of Russian Federation in Education for development of the system of continuous education for sustainable development (scientific methodological grounds and realization in Russian Federation). In 2006 research and practice proposal "Innovation Approaches in Advancement of Higher Education Based on Integration with Fundamental Sciences" for institutions of higher professional education, which accumulated the experience of the Higher Chemical College of Russian Academy of Sciences and the Higher College for Rational Use of Natural Resources (HCRUNR), was granted Russian Governmental Prize in education.

At HCRUNR there is realized one of specializations unique for chemical universities – specialization 511100 "Ecology and Natural Management" belonging to Educational Methodological Association (EMA) of classic universities. The approval of curricula and programs of the specialization is carried out by Scientific Methodological Council on Ecological Education and Sustainable Development of the EMA.

Currently, the training in this specialisation is mainly performed at geographic, biological, ecological departments of classic universities. However, examination of contemporary educational market indicates that in a fast-paced world there is demand for specialists having all-round training combining the knowledge of Earth sciences with fundamental natural science background, in particular, in chemistry.

Higher colleges and chairs of ICPSD suggest a wide variety of Master degree training programs, such as 511102 "Ecosystem Exploitation", 511105 "Natural Management", 511107 "Social Ecology", 511110 "International Cooperation in Ecology and Natural Management", 511114 "Radioecology", 511116 "Mathematical Simulation of Ecosystems", 511117 "Environmental Safety", 511118 "Urban Ecology", 511120 "Ecological Education".

To date, the most elaborated training program is Master degree in ecology and natural

management with specialisation “Ecological Education”, which has been taught for 15 years at the Higher School of environmental sciences under the supervision of G. A. Yagodin. Introduction of ecology courses in school education, ecologization of many disciplines, development of optional courses requires involvement of specialists possessing up-to-date education. They must have comprehension of contemporary challenges at the global, local and regional levels, possess systems thinking, and be capable of acting in dynamic environment. The Masters of this specialisation are highly sought by educational institutions of Moscow; thus, the program was supported by the grants of the Moscow City Government.

For development of Master degree programs of this specialisation, the program “Chemistry and Sustainable Development” was worked out at ICPSD in 2006.

Innovation educational Master degree program “Chemistry and Sustainable Development” provides the formation of professional competences and skills of a future MS in one of the most important fields of cross-disciplinary science and modern technology – environmental chemistry and green chemistry. The program is aimed at training of chemists of different specialties and environment managers in modern approaches to description of physical chemical processes in environment induced by natural and anthropogenic factors, development of environmentally friendly technologies, the techniques of complex investigation of environmental conditions and socioeconomic dynamics from the point of view of sustainable development.

Educational strategy for sustainable development accepted by UNECE in 2005 [5] recommends putting special focus on the disciplines related to the primary professional activity of specialists of a given category and the impact of their work on socio-economic environment and environmental conditions. Master degree students acquire basic understanding about physicochemical processes providing sustainability of living systems on Earth, particular features of behaviour of anthropogenic contaminants in geospheres, approaches to minimizing environmental impact of chemical and petrochemical complexes. The courses of the educational program of a Master of Science include

the modules of basic, professional and optional disciplines.

It is known that the processes determining the modern state of the biosphere are underlain by physicochemical transformations in the lithosphere, hydrosphere, atmosphere and living beings. These transformations are considered in the corresponding chemical subdisciplines: geochemistry, agricultural chemistry, photochemistry, water chemistry, biochemistry *etc.* However, global processes occurring in environment and induced both by natural and anthropogenic factors evidence the existence of close relationship between the phenomena in different geospheres involving abiotic components, and biogeochemical cycles. V. I. Vernadsky emphasized this relationship in his monograph “Chemical Structure of the Earth’s Biosphere and Its Environment”.

In the 70s of the last century a new scientific discipline emerged – the chemistry of environment. It relies on fundamental principles and ideas of the classic chemistry, but in this case the objects of investigation belong to the biosphere and other spheres of the Earth. This relatively young field of knowledge gains intensive development in Russia and other countries. Earth’s envelopes (or spheres) – atmosphere, hydrosphere, lithosphere, cryosphere, and biosphere – are tightly joined to each other by substance and energy flows, which also form specific particular systems in each of them. Therefore, the specialists in environmental protection and natural resource management must be able to forecast the consequences of introduction of new technologies, know specific features of behaviour of different chemical compounds in biosphere, estimate possible impacts on biosphere processes. This is of particular importance for elaboration and realization of the strategy of transition to sustainable development, as preservation of life on the Earth and the advance of human civilization are possible only with steady functioning of biosphere systems of life sustaining.

Masters of Science must be qualified in analysis of changes in physical chemical characteristics of environment and extraction of information necessary for solution of problems of sustainable development, be able to assess

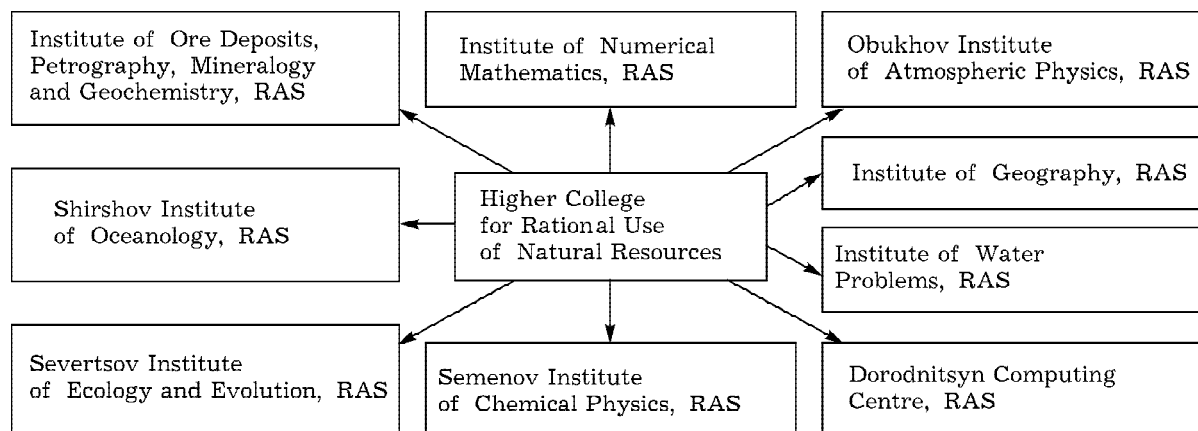


Fig. 1. Block diagram of research activities of HCRUNR students.

short- and long-term consequences of practical employment of advances in chemistry and chemical technology, know the fundamentals of green chemistry and apply it in practice, have the comprehension of the theory of contemporary methods of analysis of natural objects and specific features of modelling of physicochemical processes in environment, be capable of revealing the interrelations between natural and socioeconomic processes using computer simulations, make decisions preserving buffering capacity of the biosphere.

Master of Science students are to learn national and global experience of employment of green chemistry principles for rational natural resource management providing the enhancement of the welfare of the current generation and protection of the natural and social systems, thus allowing future generations to satisfy their demands and, therefore, ensure sustainable development of the human civilization.

Master of Science students have to participate in research on application of methods of chemistry and chemical technology for sustainable regional development in the frame of re-

search plans of the chair of problems of sustainable development, Higher College for Rational Use of Natural Resources of Mendeleev UCTR, as well of RAS Institutes involved in the educational consortium (Fig. 1).

To solve a problem, one must see its roots but not contend against particular manifestations and consequences. Education for sustainable development gives the capability of such comprehension.

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