GULNAR FARITOVNA MELNIKOVA

# DEVELOPMENT OF THE CHEMICAL EDUCATION CONTENT AT RUSSIAN UNIVERSITIES (the 90s of 20th century – beginning of 21st century)

13.00.01 – General Pedagogy,
History of Pedagogy and Education

SYNOPSIS
of the thesis for a degree
of Candidate of Pedagogic Sciences

KAZAN – 2019

The work has been performed at
Kazan (Volga region) Federal University

| | |
|---|---|
| **Academic Supervisor** | **Suriya Irekovna Gilmanshina**<br>PhD in Pedagogic Sciences, Associate Professor, Head of the Department of Chemical Education at the Chemical Institute named after A. M. Butlerov of Kazan (Volga region) Federal University |
| **Official Opponents:** | **Olga Gennad'yevna Rogovaya**<br>PhD in Pedagogic Sciences, Professor,<br>Head of the Department of Chemical and Ecological Education at Russian State Pedagogical University named after A. I. Herzen, Saint-Petersburg |
| | **Evgeny Yakovlevich Arshansky ,**<br>PhD in Pedagogic Sciences, Professor, Professor<br>of the Department of Chemistry of Vitebsk State University named after P. M. Masherov, Vitebsk |
| **Leading organization:** | Kalmyk State University named after B.B. Gorodovikov, Elista |

The defense of the thesis will take place on June 06, 2019 at 10.00 am at the meeting of the Dissertation Defense Board D 212. 081.02. at Kazan (Volga region) Federal University at: 1 Mezhlauk str., classroom 322, 420021 Kazan

The thesis can be found in the library of Kazan (Volga region) Federal University.

The electronic version of the synopsis is available on the official website of Kazan (Volga region) Federal University: www.ksu.ru and at the website of the State Commission of Academic Degrees and Titles: www.vak.ed.gov.ru

The synopsis was sent on " " , 2019.

Academic Secretary
of Dissertation Defense Board
V.G. Zakirova, PhD in Pedagogic Sciences, Professor

## GENERAL DESCRIPTION OF THE THESIS

**Relevance of the Research.** Higher education is directly related to the economy, science, technologies and the culture of society. Its development is an important part of the strategy of education development in the country. Building an efficient system of university-based chemical education in Russia is extremely important due to the intensive development of chemical, petrochemical, and pharmaceutical industries.

The relevance of this research, which focuses on the study of the development peculiarities of chemical education in a classical university located in the European region of Russia, is stipulated by several reasons. They are, first, the needs of the Russian economy, which has to find necessary approaches to the development of the chemical specialists training system for the country. Secondly, it is the involvement of the federal university in various integration processes that requires timely improvement of the higher educational system, and constant monitoring of the chemical industry development situation. Third, it is the transformation processes in the educational system, which are accompanied by the development of new models, concepts, and standards of higher education. Fourth, it is the needs of the long-term planning of higher chemical education development based on the scientifically proven forecast.

**Degree of Development of Issue.** The formation of chemical education in Russia is inextricably linked with the names of outstanding scientists, such as G. I. Hess, F. I. Giese, V. F. Zuyev, M. V. Lomonosov, N. I. Lobachevsky, V. V. Petrov, N. I. Pirogov, V. M. Severgin, N. P. Shcheglov. They have trained great chemistry researchers and educators – N. N. Zinin, N. N. Beketov, A. M. Butlerov, D. I. Mendeleev, V. V. Markovnikov, who laid the basis of the content of university-based chemical education. Further, professors of Moscow and St. Petersburg universities were regularly involved in the development and testing of the content of programs and textbooks for secondary school. They were G. I. Hess (St. Petersburg), M. E. Golovin (St. Petersburg), Ya. L. Goldfarb (Moscow), V. F. Zuev (St. Petersburg), D. M. Kiryushkin (Moscow), D. I. Mendeleev (St. Petersburg), A. M. Teryaev (St. Petersburg), N. T. Shcheglov (St. Petersburg).

The dedicated study of the issues connected with the history of university-based chemical education in Russia began in 1917. The mayor portion of scientific efforts in history and pedagogy was created in the second half of the 20th century. At the same time, a significant intensification of researches and a growth of their scientific and theoretical level were observed in 1990-2000. This issue was touched upon in the works by G. K. Budnikov, A. V. Zakharov, Yu. A. Zolotov, P. M. Luk'yanov, Yu. I. Solov'yov, V. I. Tsvetkov and others. The issues of the school-based chemical education history in Russia were studied in the works by A. N. Bratennikova, M. M. Herman, E. V. Maltseva, S. M. Marchukova, K. Ya. Parmenov, A. N. Parfenik, L. M. Smorgonsky, S. V. Teleshov and others. Some aspects of the formation and development of university-based chemical education in European countries were investigated by N. V. Sukhankina. National professional chemical education in Tatarstan was studied by N. Sh. Miftakhova.

For many years, a knowledge approach had been dominating in the domestic pedagogical theory and practice, which reflected the practice of the Soviet school,

where scientific knowledge were the basis of the content of education. In this approach, a key role is played by the selection of the subject material that enables to master knowledge of the science basics, as well as the relevant skills and abilities. Changing the view of the purpose, objectives and results of training has become one of the reasons to reform the education in the modern Russia. It was a competency-based approach widely used in the late 20th – early 21st centuries that reflected the social and economic needs of the state in training specialists, who were able to apply knowledge in practice.

The issues of the competency-based approach in the foreign and Russian science began to be dealt from the end of 1980s. The most important studies, however, date back to the early 21st century. The analysis of up-to-date scientific efforts shows that the works of the following scientists were used in the training of teachers within the competency-based approach. They were V.A. Adolf, O. V. Akulova, E. V. Baranova, I. S. Batrakova, V. A. Bodrov, G. A. Bordovsky, E. F. Zeer, I. A. Zimnyaya, T. E. Isaeva, Z. I. Kolycheva, A. K. Markova, N. F. Radionova, N. N. Surtayeva, A. P. Tryapitsyna, A. V. Khutorskoy, N. V. Chekaleva and others.

The competency-based approach and the difficulties of competence formation are analyzed in the works of the Russian researchers (E. V. Bondarevskaya, P. P. Borisov, N. S. Veselovskaya, A. A. Derkach, I. A. Zimnyaya, L. F. Ivanova, N. V. Kuzmina, O. Ye. Lebedev, A. K. Markova, L. A. Petrovskaya, N. T. Pechenyuk, T. B. Tabardanova, N. F. Talyzina, A. V. Khutorskoy, G. A. Tsukerman, V. D. Shadrikov, R. K. Shakurov, V. M. Shepel, etc., as well as foreign scientists: R. Barnett, V. Wester (Holland), J. Raven (UK) and others.

The issues developing theoretical and methodological aspects of teaching certain chemical disciplines at higher school were considered in dissertation researches of the recent years (V. V. Anshakova, N. P. Bezrukova, A. A. Budanova, O. V. Vityazeva, Yu. Yu. Gavronskaya, O. S. Zaitsev and others). The studies were carried out dealing with the training of teachers of chemistry in classical and pedagogical universities (I. Yu. Aleksashina, E. Ya. Arshansky, T. A. Borovskikh, P. D. Vasil'eva, V. P. Garkunov, S. I. Gilmanshina, M. S. Pak, L. V. Panfilova, O. G. Rogovaya, I. M. Titova, etc.), formation of chemical competences in the process of training students (O. Yu. Afanas'eva, O. V. Balachewskaya, A. I. Gritskevich, G. I. Egorova, O. V. Ershova, D. D. Iskhakova, etc.), system of continuous chemical education (S. I. Gilmanshina, E. V. Maltseva, etc.).

However, the study of development of the chemical education content at Russian universities (the 90s of the 20th century – early 21st century) has not been properly reflected in scientific efforts and has only a discussion and fragmentary nature. Moreover, the absence of such research hinders the understanding, application and extension of the gained experience, makes it difficult to predict the further development of the university-based chemical education amid its transformation.

Thus, there are **contradictions** between:

- the existing rich historical experience of development of the chemical education content in Russian universities in the 90s of the 20th century – early 21st century, and the lack of research into trends in the historical development of this issue in the pedagogical science;

- the increased need in the transformation of the higher chemical education, and the lack of a multifaceted approach to the selection of its content in Russian universities.

The mentioned contradictions have defined a **research issue**: what are the distinctive features of the formation and the major trends in the development of the content of the chemical education at classical Russian universities (in the 90s of the 20th century – early 21st century).

The relevance of the issue, its insufficient development have determined **the topic of the research**: The development of the chemical education content at Russian universities (the 90s of the 20th century – early 21st century).

**Purpose of the research:** to identify and develop formation stages of the content of chemical education at classical Russian universities and major trends of its development (the 90s of the 20th century – early 21st century).

**Target of the research:** development of the content of chemical education at Russian universities.

**Subject of the research:** formation stages of the content of the chemical education at classical Russian universities and major trends of its development (the 90s of the 20th century – early 21st century).

To achieve the goal set, the following **tasks of the research** were determined:

1. Characterize the historical and theoretical background of the formation and development of the content of higher chemical education in Russia in conjunction with the social and economic conditions of the respective period.

2. Identify the main stages in the development of the content of university-based chemical education in Russia in the second half of the 20th century – the early 21st century.

3. Develop the leading trends in the development of the content of university-based chemical education in Russia in the second half of the 20th century – the early 21st century.

4. Identify and develop a variable model of modern chemical education and forecasting trends amid its transformation through the example of Kazan Federal University.

**The background of the research** was**:**

- conceptual ideas on the main stages of the formation and development of chemical education in Russia (works of G. K. Budnikov, A. V. Zakharov, N. Sh. Miftakhova, V. I. Tsvetkov);

- conceptual studies on the history of pedagogy and education (M. V. Boguslavsky, R. A. Valeeva, V. F. Gabdulkhakov, etc.), the history of formation and development of higher professional education (S. A. Aref'eva, G. I. Ibragimov, V. A. Komelina, Yu. A. Kustov, etc.), the theory of selection of the content of education (A.V. Grebenshchikova, V. G. Maksimov, A. K. Markova, M. I. Skatkin, etc.), the education theory and methodology (L. A. Volovich, V. I. Zagvyazinsky, O. G. Maksimova, M. I. Makhmutov, N. F. Talyzina, etc.);

- the following scientists of Kazan University made a significant contribution to the development of chemical education: A. E. Arbuzov, B. A. Arbuzov, A. M. Butlerov, A. M. Zaitsev, N. N. Zinin, K. Klaus, A. I. Konovalov, V. V. Markovnikov and others.

- the provisions for implementation of the competency-based approach in education (I. A. Zimnyaya, N. V. Kuzmina, A. K. Markova, J. Raven, A.V. Khutorskoy, etc.); applied aspects of the formation of competencies of students, i.e. future teachers (A. G. Akhmetov, S. I. Gilmanshina, A. I. Gritskevich, S. G. Dobrotvorskaya, V. G. Zakirova, D. D. Iskhakova, P. P. Terekhov, A. N. Khuziakhmetov, I. E. Yarmakeev);

- theoretical and methodological specifics of teaching chemical and pedagogical disciplines at high school (V. V. Anshakova, E. Ya. Arshansky, N. P. Bezrukova, A. A. Budanova, P. D. Vasilyeva, O. V. Vityazeva, Yu. Yu. Gavronskaya, O. S. Zaitsev, M. S. Pak, O. G. Rogovaya, N. V. Sikhankina, etc.).

**Methods of the research:**

- *methods of theoretical knowledge* – retrospective and historical-and-logical system analysis, analogy, abstraction and specialization, modeling, forecasting; analysis of historical-and-pedagogical and historical-and-chemical literature, of scientific-and-methodical literature, of archival documents for the period investigated; classification of chemical education development stages;

- *methods of empirical knowledge* – analysis of documents, websites, roadmaps, curricula and programs of disciplines; generalization of scientific, pedagogical and organizational activities of the university teachers, study of practical competencies of teachers, questionnaires, observation, conversations.

**Stages of the research.** The research was carried out in the period of 2013 to 2018 in three stages.

*The first theoretical and search stage* was linked with the choice of research topics, the definition of methodological and theoretical basis, clarifying the goals, and the objectives, as well as identifying the state of the issue study in the scientific theory and practice of education. At this stage, the theoretical and practical state of teaching chemical disciplines at Russian classical universities was studied. Literary sources on historical and pedagogical bases, archival materials, publications on problems of chemical education in Russia and abroad were analyzed.

*The second (research) stage* was characterized by carrying out an in-depth analysis of the issue using archival materials, Russian legislation, organizational documents and regulations, decisions of the Academic Board and the Board of Guardians, speeches of the rector of Kazan University, roadmaps of the Chemical Institute named after A. M. Butlerov. This made it possible to reliably identify and substantiate the main stages, principles and trends in the development of the content of university-based chemical education in Russia; to identify and develop a variable model of the content of modern chemical education and its forecasting trends through the example of Kazan Federal University.

*The third (summary) stage* was devoted to the systematization and processing of research results, summation of materials, design of the thesis.

**The scientific novelty** of the research is as follows:

1. Historical and theoretical background of the formation and development of the content of higher chemical education in Russia in the 90s of the 20th century – the beginning of the 21st century have been developed and characterized on the basis of a systematic analysis: *political* (interrelation between the development of chemical education and features of the country's political system, a process of regionalization of education), *social and economic* (development of the chemical industry and

advanced technologies, need of formation of natural and scientific world outlook in all spheres of life activity; training of mobile highly qualified chemists having organizational, administrative and communicative skills), *historical and pedagogical* (introduction of federal educational standards, creation of a regulatory framework of the higher chemical education, arrangement of up-to-date laboratories, emergence of new information technologies, introduction of new courses in curricula, which meet modern requirements), *scientific and pedagogical* (relevance of the development of chemical science in the country and in the world; expanding the range of chemical disciplines in higher education institutions).

2. The stages of development of chemical education in Russia in the first half of the 18th century – the beginning of the 21st century have been identified and substantiated:

*Stage 1* – the absence of independent status of chemistry as a science and a separate discipline (1725-1804); *stage 2* – the emergence of chemical education (1804-1840); *stage 3* – the formation of chemical education elements (1840-1861); *stage 4* – fundamentalization of chemical education (1861-1900); *stage 5* – search for the content and methods of chemical education (1900-1929); *stage 6* – focusing research and training on the needs of production; start of training teachers of chemistry (1929-1955); *stage 7* – dividing into two areas of training of chemists in universities – industrial and pedagogical; development and improvement of educational programs (1955-1985); *stage 8* – regionalization of chemical education (1985-1991); *stage 9* – reformation of education, adoption of new laws on education (1991-2000); *stage 10* – modernization (implementation of a competency-based approach) (2000-2010); *stage 11* – transformation of higher chemical education (2011 to the present day).

3. The main trends in the development of the content of the current higher chemical education in Russia (interdisciplinary, internationalization, transformation) have been identified and substantiated.

In terms of structure and content, the higher chemical education in Russia includes classical chemical education, chemical and technological education and chemical and pedagogical education. Each of them became a priority at various historical periods, starting from the second half of the 20th century. In 90s of the 20th century – the early 21st century, all three professional areas of the chemical education (research and classical chemical; technological; pedagogical) formed at the classic Kazan university. This process of changing the content of the classical university-based chemical education was most clearly marked out by the establishment of federal universities since 2011.

4. The structure of a variable model of current chemical education at Kazan Federal University including two-level classical chemical and chemical-and-technological education, as well as a two-level distributed model of the chemical and pedagogical education, has been identified and developed. The activity of teachers has been carried out in three directions – education, science, and production – through the implementation of strategic academic units, which included various chemical areas of training.

**The theoretical significance of the research** lies in the presentation of an entire system of the university-based chemical education development in Russia, which combines the different stages of the historical period investigated; in the

introduction into scientific use of historiographic materials enabling to expand the possibilities of the museum pedagogy in the educational process of the university-based education, to make a real contribution to the development of theory and methods of teaching. The identified prerequisites and forecasting trends of the higher chemical education development in Russia using the federal university as an example will serve as a guide in solving the problems of teaching chemical disciplines and training teachers of chemistry in Russian universities.

**The practical significance of the research** is determined by the fact that its results make it possible to improve the activities of universities in the field of chemical and chemical-and-pedagogical education, contribute to the summation, systematization and use of historical and pedagogical heritage of chemical scientific schools in the teaching and educational process of Russian universities. The materials of the thesis can be further used for more detailed content of training courses on the theory and history of pedagogy, in training courses, for preparation of teaching guides, while writing monographs, and developing training courses on the formation of super subject competencies.

The author has developed such disciplines as B1.V.OD.3 History and Methodology of Chemistry, B1.V.DV.5.2 Role of Chemistry in Development of Natural Science Expertise, B1.V.DV.15.1 Development of Chemistry in Kazan, B1.V.DV.15.2 Kazan Chemical School, B1.V.DV.6.2 Chemical Production of Tatarstan; such interactive projects for students as Chemistry and its Role in Human Life, Chemical Glass. From Retort to Fractioning Column; a system of historical and chemical tasks using museum exhibits, training courses, etc., and implemented them in the educational process of the university program.

Published monographs – Life of A. M. Butlerov. Historical and Biographical Collection (individual, with the volume of 383 p.), Nikolay Nikolayevich Zinin. Historical and Biographical Collection (collective, with the volume of 431 p.) will be useful for teachers of universities, teachers of urban and rural schools, for the system of additional education and development of education workers.

**The reliability and feasibility of the scientific results obtained** are supported by the modern methodological base of scientific knowledge; by the implementation of initial theoretical data and a conceptual-and-terminological set of research; by adequacy of logic and research methods to its subject, goals and objectives; by conducting scientific research along with practical activities; by consistency of the findings with modern scientific ideas about the role of the chemical education in the innovative development of the country; by the results and conclusions that were formulated and published in the works of the author.

**Approbation and implementation of the research results** were performed by printed and oral presentations at international and university-based conferences, meetings of the Department of Chemical Education of Chemical Institute named after A. M. Butlerov as well as at methodological workshops of the Institute of Psychology and Education of Kazan Federal University, during a long-standing pedagogical activity at the museum of Kazan Chemical School and in the educational process of the federal university.

The basic concepts, ideas, research results have been presented at 10 international scientific, scientific-and-practical and methodological conferences in

Russia and abroad (Astrakhan, 2017, Brest, 2015, 2017, Minsk, 2015, Moscow, 2017, Kazan, 2014 (two), Kaunas, 2013, St. Petersburg, 2013, 2016).

The key results have been published in periodicals, including three articles in such journals recommended by the State Commission for Academic Degrees and Titles of the Russian Federation as Modern Issues of Science and Education and Chemistry at School, and six articles were published abroad (four of them – in publications indexed in WoS and Scopus databases). 28 works have been published in total, including two monographs with volumes of 383 and 431 pages, which are tested and used in practical classes on relevant disciplines at universities, IT-lyceum of Kazan Federal University, schools and gymnasiums of Kazan.

The author's ideas embodied in interactive expositions at the Touch the Science National Exhibition (16.02.2016, Kazan), the House of Art (2015, Kazan), in the Best Curator contest, have been marked by diplomas and are used in extracurricular activities of students, i.e. future teachers during their pedagogical practice at schools and gymnasiums of Kazan.

Six author's programs of disciplines were tested and introduced into the educational process of the Department of Chemical Education of Kazan Federal University, which is confirmed by the certificates of introduction.

**The personal participation** of the author means obtaining scientific results stated in the thesis and published in printed works, theoretical development of the main scientific ideas and provisions of research. Of great importance was the long experience of the applicant Director of the Museum of Kazan Chemical School, assistant to the Department of Chemical Education and head of course and final qualifying works of students, i.e. future teachers of chemistry, as well as a mentor on the formation and development of over-subject "breakthrough" competencies (soft skills*)* (2015-2020 Talent Management Strategy in the Republic of Tatarstan State Program).

**The following issues will be considered at the thesis defense:**

1. Historical and pedagogical prerequisites for the development of the content of higher chemical education in Russia (in the 90s of the 20th century – early 21st century.): political, social and economic, historical and pedagogical, scientific and pedagogical.

2. Theoretical substantiation of the identified stages, trends in the formation and development of the content of higher chemical education in Russia (in the 90s of the 20th century – early 21st century). From the first half of the 18th century to the present, eleven stages have been totally determined, which were characterized in the relevant years by: absence of the independent status of chemistry as a science and a separate academic discipline; emergence of chemical education; formation of its principles; fundamentalization; search of content and methods; focus in studies and training on the needs of production, beginning of the training of teachers of chemistry; separation into two areas of training chemists at universities - production and pedagogical, development and improvement of educational programs; regionalization; reformation, adoption of new laws on education; modernization (introduction of competency-based approach); transformation. The last three stages, i.e. reformation, modernization, and transformation, belong to the period researched. The key trends in the development of the content of the modern higher chemical education in Russia are interdisciplinarity, internationalization, and transformation.

All the structural and content components (research or classical, technological, pedagogical) of the chemical education have historically formed at the classical Kazan university. After a period of differentiation into specialized universities, starting from 2011 with the formation of federal universities, changes in the content of classical university-based chemical education are clearly observed.

3. The identified structure of a variable model of the content of modern chemical education and forecasting trends amid its transformation. 4. The structure of the variable model of the modern chemical education at Kazan Federal University includes two-level classical chemical and chemical-and-technological education, as well as a two-level distributed model of the chemical and pedagogical education. The structural model contains the following units:

– target unit (target: to form a competitive graduate of the university by means of chemical education; tasks: to form professionally significant competences; to strengthen motivation for professional practice-oriented activity; to form professional thinking; to bring up morality and nationhood, an ability of professional reflection and health saving by means of chemistry).

– methodological unit (initial methodological provisions providing structure planning and designing of the content and methods of training in accordance with the purpose and focus on the development of mechanisms for the implementation of the Federal State education Standards are the following approaches: system-based activity, competence, integrative aspect and innovativeness of pedagogical activity; principles: focus on practice, variability, network interaction, academic mobility, adaptability, innovativeness).

– content-related unit (based on the content of professional activity adapted to the courses of disciplines of the two-level chemical education: research activities in the field of chemistry; chemical and technological activities; chemical and pedagogical activities).

– technological unit (includes technologies implemented in the educational process of Kazan Federal University. These are modern educational technologies presented in the programs of disciplines based on the integration of conventional technologies of teaching chemistry along with innovative ones (computer, Internet-based technologies, electronic educational resources, computer modeling, etc.); innovative technologies of strategic academic units, scientific and educational centers, technologies of grant programs, academic mobility and internationalization; technologies of network interaction with industrial centers, import substitution, complex project technologies to create high-performance production).

– resultant unit (includes the result – a university graduate possessing a set of competencies being in demand in the labor market in accordance with the educational standards of the new generation).

In general, the content of the activities of university teachers (educational, scientific, production) is manifested through the implementation of strategic academic units that include various chemical areas of training.

**The structure and scope of the thesis.** The thesis consists of introduction, two chapters, conclusion, list of used literature (209 items), three appendices. The volume of the main text is 184 pages, includes 4 tables, and 2 figures.

## BASIC CONTENT OF THE THESIS

*The introduction* describes the relevance of the topic, the degree of its development, the scientific set of research, novelty, theoretical and practical significance, the main provisions to be considered at the thesis defense.

*The first chapter "Historical and Theoretical Prerequisites of Formation and Development of the Content of Russian Higher Chemical Education in Conjunction with the Social and Economic Conditions of the Period under Review*" describes and characterizes historical and pedagogical prerequisites of formation of chemical education; identifies and substantiates the main stages, principles and trends of its formation and development since establishment of the first three universities in Russia until the beginning of the 21st century; identifies trends in chemical education and its structural and content features in conjunction with political and social and economic conditions of the period under review; studies didactic conditions and peculiarities of organization of chemical disciplines teaching at the Russian university.

*In § 1.1.* Historical Background of the Formation of Higher Chemical Education Content in Russia (the 18th century – early 20th century.), the analysis of research is carried out, which allowed to identify 4 stages of chemical education system development: *Stage 1* – the lack of independent status of chemistry as a science and a separate discipline (1725-1804); *stage 2* – the emergence of chemical education (1804-1840); *stage 3* – the formation of the foundations of chemical education (1840-1861); *stage 4* – fundamentalization of chemical education (1861-1900).

The results of the research allow us to assert that the first departments of chemistry appeared in the first half of the 19th century on the basis of physical and mathematical faculties (departments) at the universities of Russian cities of Moscow, Kazan, St. Petersburg, Kharkov, etc. The opening of a chemical laboratory at Kazan University in 1837 played a significant role in the formation and development of chemical education in Russian universities. By mid-19th century, the position of chemistry as an independent academic discipline in secondary and higher educational institutions strengthened. Teaching plans have been developed to streamline the content of training of chemists in Kazan, later in Moscow and Novorossiysk universities.

Thus, by the end of the 19th century, the content of chemical education got to a completely new level, the programs of chemical and science disciplines were brought into compliance with the development level of new areas of chemistry.

The analysis of archival materials suggests that the development of the content of chemical education has always been associated with the updates of its applied nature. Scientists have faced many practical problems due to the switch from manufactories to plants and factories. This led to the fact that the educator scientist was replaced by a natural scientist, who saw his task in the practical application of scientific knowledge.

During the research it was found out that the second half of the 19th century was characterized by forming chemistry as an independent science, which had its own subject of study, own fundamental theories and concept. By the end of the 19th century, scientists of Russia and abroad produced and explored tens of thousands of new organic and inorganic substances. Fundamental laws were discovered and generalizing theories were created. The achievements of the chemical science were

applied in industry. Chemical laboratories and physical-and-chemical scientific institutes were built and modernly equipped. This served as a scientifically substantiated prerequisite for the formation of a new structure of university-based chemical education in Russia and the formation of methods of teaching chemistry as an independent discipline in higher and secondary school.

In general, the formation and development of the content of chemical education in Russia at the end of the 19th century – the second half of the 20th century was characterized by the compilation of the first curricula, the beginning of the development of methods and forms of teaching, and by substantiation of the role of experiments. A great role of scientists and chemists of Kazan University like K. Klaus, N. N. Zinin, A. M. Butlerov, V. V. Markovnikov, A. M. Zaitsev, A. E. Arbuzov, B. A. Arbuzov and others lied here. One of the important areas of development of chemical education in this period was engineering and technology. Two systems of training teachers of chemistry appeared, one of which implied training in classical universities, and the other - in pedagogical institutes.

By the beginning of the 20th century, the priority area of chemical science became the organic chemistry, which determined the substantive changes in chemical education.

*In § 1.2. Development of the Content of Higher Chemical Education in Russia (the first half of the 20th century),* three stages of its development at Russian universities have been identified. These are – as a continuation of stages described in *§ 1.1 – stage 5* – search for the content and methods of chemical education (1900-1929); *stage 6* – focusing research and training on the needs of production, the beginning of training teachers of chemistry (1929-1955); *stage 7* – the division of the two areas of training chemists at universities – industrial and pedagogical, and development and improvement of educational programs (1955-1985).

The research illustrated that this period of development of the higher chemical education in Russia passed in line with the trends, which became characteristic of higher education since the first years of the Soviet regime. In June 1920, the resolution of the Council of People's Commissars On Higher Technical Educational Institutions was adopted, and in 1921 – the resolution of the Council of People's Commissars On Measures to Raise the Level of Engineering Knowledge in the Country And to Improve the Living Conditions of Engineering and Technical Employees of the Russian Soviet Federative Socialist Republic. Thus, in the 20th century, the Russian chemical industry became a strong scientific and technical industry, which took one of the leading positions in the country's economy.

The content of chemical education has also assumed a direct professional orientation while focusing on training, first, researchers in the field of chemistry and related sciences and chemical engineers. The development of chemical science and the urgent need for specialists with higher education initiated the processes of combining chemical departments into independent units.

Unprecedented growth in the scale of chemical production in the 30s, the complexity of their nature had a direct impact on the entire complex of chemical sciences and the training system for the chemical industry. On April 28, 1928, a decree On Measures of the National Economy Chemization in the USSR was issued. A chemical unit was established in the State Planning Committee (Gosplan) to elaborate long-term chemization plans. The Supreme Council of National Economy

and Gosplan had to enhance the pace of development of the chemical industry. However, there was a serious shortage of specialists, and it became an important problem of the state.

During the study of the array of publications devoted to the development of the content of chemical education, it was defined that the focus of the content of higher chemical education and training on the needs of production initiated the relevant processes in the school. Progressive changes in the content of the school chemical education happened owing to the methodological activities of such well-known scientists, as S. I. Sozonov (St. Petersburg), V. N. Verkhovsky (St. Petersburg), S. G. Krapivin (Novorossiysk, Moscow), D. M. Kiryushkin (Moscow), P. A. Gloriozov (Moscow), Yu.V. Khodakov (Moscow). In 1932-1933, the first stable programs and textbooks on chemistry for secondary school were issued (V. N. Verkhovsky, S. A. Balezin), in which a special attention was paid to the chemical experiment. S. I. Sozonov conducted the first practical classes in chemistry in secondary school. Together with V. N. Verkhovsky, he has established the first chemical laboratory. In 1937, the scientific and methodical journal Chemistry at School began to be published. The works of the staff of the chemistry teaching methods laboratory at the USSR Academy of Pedagogical Sciences (Moscow) were issued. The works on the history of teaching chemistry in the Soviet and foreign secondary school and on the formation of methods of natural sciences became important in the area of teaching methods.

Thus, the objective conditions of the second half of the 20th century linked with the development of chemical production and scientific and methodological section in education have affected the content of the university-based chemical education in Russia. For instance, along with the traditional specialization in the main chemical disciplines in universities, there was a need to introduce specializations focused on training chemists for specific areas of activity, including work in the field of education (teaching). That means, one of the priorities of university-based chemical education in Russia has become the formation of a system of training teachers of chemistry at universities (Moscow, Kazan, St. Petersburg).

During elaboration of new curricula, the emphasis was placed on enhancement of the pedagogical training of students of natural science faculties in order to raise it to a higher scientific level. At the same time, the resource of the classical school system began to move away from the development of modern science, as it was not associated with the rapidly developing computer science and did not take into account the new achievements of psychology and pedagogy. Pedagogical institutes, however, continued to be the main cluster of training of future teachers.

Thus, based on retrospective and historical-and-logical system analysis, the historical and theoretical background of formation and development of the content of higher chemical education in Russia in terms of political, social and economic, historical-and-pedagogical and science-and-pedagogical aspects has been discovered and characterized. *Political background:* interrelation of the development of chemical education with the peculiarities of the political system of the country, with the process of regionalization of education. *Social and economic background:* development of the chemical industry and modern technologies, the need to form a natural science world view in all the spheres of life; training of highly qualified mobile chemists with organizational, administrative and communication skills.

*Historical and pedagogical background*: introduction of the state educational standard, creation of a regulatory framework for higher chemical education, arrangement of modern laboratories, emergence of new information technologies, inclusion of new subjects meeting current requirements in the curricula. *Science and pedagogical background*: relevance of the development of chemical science in the country and the world; expanding the range of chemical disciplines in higher educational institutions.

*In § 1.3. Trends in the Development of the Content of Chemical Education at Universities in the Second Half of the 20th century - Early 21st Century,* additional four stages are identified and substantiated. Continuing the consecutive numbering, we get: *Stage 8* – regionalization of chemical education (1985-1991); *stage 9* – reformation of education, adoption of new laws on education (1991-2000); *stage 10* – modernization (implementation of the competency-based approach) (2000-2010); *stage 11* – transformation of the system of higher chemical education (from 2011 to the present day).

Thus, based on the analysis of historical and pedagogical literature, archival materials devoted to history of chemistry and chemical education, 11 stages of formation and development of university-based chemical education in Russia since the beginning of the 18th century to the present day were identified and substantiated.

Classical chemical, chemical-and-technological and chemical-and-pedagogical education were identified at different stages of development of the system of higher chemical education in Russia. Each of them became a priority at various historical periods, starting from the second half of the 20th century to the present day.

The basic principles of the development of modern higher chemical education in Russia were identified and substantiated based on a system analysis of Russian legislative acts, organizational documents and regulations, decisions of the Board of Academics and the Board of Guardians of Kazan Federal University and in accordance with the progress of public life. Those principles are focus on practice, variability, network interaction, academic mobility, adaptability, innovativeness. The implementation of these principles determined the priorities of updating the content of chemical education (implementation of the competency-based approach, computerization, regionalization, and greening) and current trends in its development (internationalization, integration, transformation, interdisciplinarity). The thesis describes in details the principles and priorities of updating the content of chemical education.

The current trend of *internationalization* of chemical education is reflected in the expansion of international cooperation and exchange of students, and teachers; in the transition to flexible curricula and the development of international educational programs; in the wide use of modern information technologies and the development of distance learning.

*Transformation.* One of the key requirements a modern university faces is the need to meet the requirements of economic feasibility. It was the increased demand for applied knowledge that led to the transformation of the university-based classical chemical education in Russia partially to chemical-and-technological and chemical-and-pedagogical ones. The necessity to transit to a system-and-activity-based paradigm of the educational process and the widespread use of information and communication (computer) technologies, the need to integrate higher education into

the system of continuous environmental education and global educational networks also influenced the transformation of higher chemical education.

*Interdisciplinarity.* This trend is reflected in opening new interdisciplinary areas of training that influence the content of education and entail the creation of new structural units (departments, laboratories). These processes are caused by the high degree of differentiation of chemical science, which is a consequence of improving its methodological base, and expanding research capabilities. Internal communication between the different sections of chemistry and its interscience connections with physics, mathematics, biology, geology, and other basic and applied sciences, with computer sciences and computer modeling determine the interdisciplinarity in the content of chemical education.

*The second chapter "Modern Trends in the Development of Scientific and Educational Content, Changes in the Structure and Technologies of Russian Chemical Education through the Example of Kazan Federal University"* reviews and analyzes the update of the scientific and educational content of higher chemical education in the context of changes in its structure and training technologies; substantiates a variable model of modern chemical education introduced in the educational process, and forecasting trends in the context of its transformation through the example of Kazan Federal University.

*In § 2.1. Update of the Scientific Content of Chemical Education*, the research showed that, in addition to federal laws, organizational documents and regulations, the update of the content and the model of university-based chemical education is influenced by the needs of society and economy, which is mediated by the results of scientific researches of the leading university teachers.

The 20th century in Russian chemical education is inextricably linked with the names of academicians A. E. and B. A. Arbuzovs, who have been heading the Kazan school of chemists for a long time (1911-1991). The results of scientific research of their followers (E. G. Kataev, A. I. Konovalov, A. N. The Pudovik) have influenced changes in the content of chemical education (classical, chemical-and-technological and chemical-and-pedagogical).

The academician A. I. Konovalov as the head of the Department of Organic Chemistry from 1974 to 1999 was one of those, who organized the integration of basic science and higher chemical education, established and supervised the leading Russian scientific school Calixarenes-Based Supramolecular Systems. His successor has been I. S. Antipin, a current Associate Member of the Russian Academy of Sciences, who develops the research areas related to calixarenes-based supramolecular systems (from synthesis to materials, biofunctional chemistry for imaging tumors, chemoinformatics for developing new drugs and translational medicine, schemes of recycling the phytomass of plants in order to create practically valuable compounds). International OpenLabs are established, and grant initiatives are successfully implemented.

The development of modern chemical and technological sector at the Kazan University is connected with Professor B. N. Solomonov (student of A. N. Konovalov), who headed the Department of Physical Chemistry in 1997. He has began his activity as a head of the Department with updating the curricula for special courses of the Department, in-depth teaching all the sections of the physical chemistry course (thermodynamics, kinetics and catalysis, electrochemistry) to

students. Today, the Department operates research laboratories (Industrial Catalysis; Homogeneous Catalysis; Rheological and Thermo-Chemical Researches). In accordance with the decree of the Government of the Russian Federation dated April 9, 2010 No. 218 On Measures of State Support for Development of Cooperation of Russian Higher Education Institutions, State Science Institutions and Entities Implementing Comprehensive High-Tech Production Projects under the "Institutional Development of Research Sector" Subprogram of the "2013-2020 Development of Science and Technology" State Program of the Russian Federation, the work on large-scale grants is being carried out successfully.

A.N. Pudovik, Associate Member of the Russian Academy of Sciences (student of A. E. Arbuzov) made a great contribution to the development of organophosphorus compounds chemistry that turned out to be very promising for practical use in medicine, agriculture and other fields. In 1948, with the participation of A. N. Pudovik, a Department of Synthetic Rubber was established at Kazan University. In 1962, it was renamed as the Department of Polymer Chemistry, in 1988 – as the Department of High-Molecular and Organoelemental Compounds. Further, the Department was headed by the student of A. N. Pudovik, Professor R. A. Cherkasov, the Honored Worker of Science of the Russian Federation (2002), who made a great contribution to the chemistry of biologically active substances.

A generation bridge is not broken even today; from 2009 to the present, the head of the Department is Professor V. I. Galkin, Associate Member of the Russian Academy of Sciences, Laureate of the State Prize of the Republic of Tatarstan (2016), Director of the Chemical Institute named after A. M. Butlerov. For the first time in theoretical organic chemistry, he has studied the mechanisms of the most important registered organophosphorus reactions underlying the production of modern drugs, protective agents and growth stimulants of agricultural plants, as well as other practically useful substances; in the field of applied chemistry – he has identified the mechanisms of action of the most common film tanning agents, while having offered new effective tanning agents on this basis.

The results of scientific researches conducted by scientists of the Kazan chemical school impacted the changes in the content of the Russian university-based chemical education. They also were reflected in the content of the disciplines and elective courses contained in the curricula of the "04.03.01 Chemistry" bachelor's program, and in establishing new in-demand master's programs like "Methods of Analytical Chemistry", "Chemoinformatics and Molecular Modeling", "Chemistry of Supramolecular Nano- and Biosystems", "Physical and Chemical Methods of Research in Chemistry", "Petrochemicals and Catalysis", "Medical Chemistry" supported by appropriate teaching and learning materials.

*In § 2.2. The Model of Modern Chemical Education at the Federal University amid Changing its Structure, Updating the Educational and Methodological Content and Learning Technologies*, the activities in the field of chemical and pedagogical education, which is inextricably linked with Kazan Chemical School, have been discovered. By chemical and pedagogical education, we understand the development of the system of training of chemistry teachers for schools and universities. Under the discipline of "04.05.01 Fundamental & Applied Chemistry Majoring in Chemist. Teacher of Chemistry", in addition to general professional chemical disciplines and courses on specialization (they are about 70% of total number of disciplines), the

curriculum contains social sciences, humanities, psychological and pedagogical subjects, which in turn provides fundamental professional training for future teachers. However, the core responsibility for chemical and pedagogical education (training of future teachers of chemistry, advanced training of teachers and their retraining, career guidance and practice-oriented chemistry training of gifted youth) is borne by the Department of Chemical Education, which graduates in the discipline of "44.03.01 Pedagogical Education Majoring in Chemistry". Its graduates (bachelor's degree) successfully pass the certification by the employer, which is the relevant ministry of the Republic of Tatarstan, and continue training within the master's program majoring in Chemical Education.

The Department of Chemical Education was included in the Chemical Institute in 2011 following the formation of Kazan Federal University. N.A. Iznoskov, a graduate of the Kazan University, stood at its origins at Kazan Pedagogical Institute, and in 1934, the newly created Department was headed by A. A. Ivanov (student of A. E. Arbuzov). The uniqueness of the Department is that for many years its teachers have successfully conducted researches in the field of organophosphorus (A.E. Arbuzov, etc.) and organoarsenic compounds (G. Kh. Kamay, etc.), as well as the scientific and pedagogical sector has developed, where candidate and doctoral theses in the field of general pedagogy have been defended. Today, the main scientific sectors of the Department are theory, methodology and practice of chemical education in the context of competency-based approach; system of pre-university training of students in chemistry and practice-oriented training of gifted youth. The results of chemical and pedagogical research are reflected in the content of modern practice-oriented methodological disciplines, historical and chemical courses of the curriculum of the bachelor's degree program. They are also given in the content of the curriculum disciplines of the pedagogical master's degree on the program Chemical Education and in the relevant educational literature (including the publications under the stamp of the profile Education and Methodological Association of the Russian Federation).

The research showed that specific character of the modern model of higher chemical and pedagogical education is in a distributed two-level training that takes into account the scientific and educational potential of the world-famous Kazan chemical school accordingly, and a powerful psychological and pedagogical potential of the university. The bachelor's degree of training is carried out at the field-specific Chemical Institute, and the master's degree – at the Institute of Psychology and Education of Kazan Federal University.

An innovative component of scientific and pedagogical support for the distributed model of chemistry teachers training is linked with attraction of highly qualified human resources and the most advanced educational and laboratory facilities of the relevant institute; integration of conventional and computer technologies of training; continuous pedagogical practice in chemistry; increase of motivation to get a teacher's profession through implementation of profession-oriented projects (Small Chemical Institute, Festival of Chemistry, etc.).The main innovative factor in the formation of practical competencies is the introduction of a unique center of chemistry teachers practical competencies. Pedagogical conditions of practical competences formation for future teachers of chemistry amid the transformation of chemical education are discovered: development and inclusion of modern practice-oriented

methodological disciplines in the curriculum; development and practical testing of group interactive projects for students of schools, gymnasiums, and lyceums by university students; organization of annual scientific and practical conferences and educational competitions for university students. Thanks to the implemented innovations, the distributed model of chemistry teacher training allows to achieve a high level in the formation of subject competencies, which is confirmed by the positive results of graduates' certification by the employer.

From all has been said it follows that the modern Russian chemical education at the federal university taking into account its changing structure, updating scientific and educational content and technologies of the training, includes the following triad: research activities in the field of chemistry, chemical and technological activities, chemical and pedagogical activities.

During the research, the current variable model of modern higher chemical education through the example of Kazan Federal University is identified and developed. It performs an educational, developmental and profession-adaptive function. The model consists of five units: target, methodological, content-related, technological, and resultant. The specifics of the pedagogical model is in its dynamism, which is put in the content-related and technological units.

*In § 2.3. Forecasting Trends of Development of Chemical Education amid the Implementation of Innovative Technologies of Training*, forecasting trends of development of chemical education through the example of Kazan Federal University are identified. The forecast is based on the unity and interrelation of its components: based on the social demand, research objectives, principles and a set of conditions to promote the development of chemical education, mechanisms to achieve the desired result, criteria, and the planned result. Forecasting trends are based on the key principles of the development of the content of chemical education (practice-oriented, variability, networking, academic mobility, adaptability, innovation) and are associated with changes in the field of education.

Thus, the analysis of modern trends in Russian university-based chemical education and its variable model by the example of Kazan Federal University, the leading federal university of Russia, allowed to substantiate the forecasting trends in the further development of university-based chemical education. These are the expansion of international links with scientific, educational and industrial centers; high international recognition and publication activities; international accreditation of educational programs in English; increase in the number of scientific and pedagogical staff. At the same time, various approaches to the development of forecasts were considered taking into account the social demand in a university graduate with certain competencies.

The *conclusion* has the following **summary:**

1. Historical and theoretical background of the formation and development of the content of higher chemical education in Russia in the 90s of the 20th century – the beginning of the 21st century have been characterized on the basis of a systematic analysis: political, social and economic, historical and pedagogical, scientific and pedagogical.

2. Three stages of the development of chemical education in Russia in the 90s of the 20th – early 21st centuries are defined: reformation (1991-2000), modernization (2000-2010); transformation (2011 to present).

3. The leading trends in the development of the content of university-based chemical education in Russia in the second half of the 20th – early 21st centuries (interdisciplinarity, internationalization, transformation) are developed.

In terms of structure and content, the higher chemical education in Russia includes classical chemical education, chemical and technological education and chemical and pedagogical education. Each of them became a priority at various historical periods, starting from the second half of the 20th century. In the 90s of the 20th century – early 21st century, all three professional areas of chemical education (research-and-classical chemical, technological, and pedagogical) formed at the classical Kazan university. The process of changing the content of the classical university-based chemical education was most clearly marked out by the establishment of federal universities, starting from 2011.

4. A variable model of current chemical education at Kazan Federal University including two-level classical chemical and chemical-and-technological education, as well as a two-level distributed model of the chemical and pedagogical education, has been identified and developed. Its graphical interpretation consisting of the target, methodological, content-related, technological, and resultant units is elaborated. The specific nature of the pedagogical model is associated with its variability and dynamism contained in the content-related and technological units.

5. The specific nature of the modern chemical and pedagogical education at Kazan Federal University is associated with the implementation of a two-level distributed model of training of future teachers of chemistry. The most significant advantage of it is that the bachelor's degree of training is carried out at the specialized Chemical Institute named after A. M. Butlerov, and the master's degree – at the Institute of Psychology and Education of the Kazan Federal University (in each of these institutions, a powerful scientific and educational potential in chemistry and pedagogy with psychology, respectively, is concentrated).

An innovative component of scientific and pedagogical support of the distributed chemistry teachers training model is discovered. The point of it is that thanks to the implemented innovations, this model allows to achieve a higher level in the formation of subject competencies, which is confirmed by the positive results of graduates' certification by the employer. An innovative component of the subject-based training implies the attraction of highly qualified human resources and the most advanced educational and laboratory facilities of the relevant institute; integration of conventional and computer technologies of chemistry training; continuous pedagogical practice in chemistry; increase of motivation to get a teacher's profession through implementation of profession-oriented projects (Small Chemical Institute, Festival of Chemistry, etc.).The main innovative factor in the formation of practical competencies is the introduction of a unique center of chemistry teachers' practical competencies. Pedagogical conditions of practical competences formation for future teachers of chemistry amid the transformation of chemical education are identified and substantiated: That is development and inclusion of modern practice-oriented methodological disciplines and historical and chemical courses in the curriculum; development and practical testing of group interactive projects for students of schools, gymnasiums, and lyceums by university students; organization of annual scientific and practical conferences and educational competitions for university students.

6. Forecasting trends of the development of the Russian university-based chemical education are identified and developed. These are the expansion of international links with scientific, educational and industrial centers; high international recognition and publication activities; international accreditation of educational programs in English; increase in the number of scientific and pedagogical staff. Various approaches to the development of forecasts were considered taking into account the social demand in a university graduate with certain competencies.

Along with this, the research showed that the problem of the development of Russian higher chemical education gives reserves for solving private issues and is closely related to its further improvement taking into account new social and economic conditions.

**The main content and results of the research are reflected in the following publications of the author:**

***Articles published in leading peer-reviewed scientific journals and publications, which were determined by the State Commission for Academic Degrees and Titles of the Russian Federation:***

1. Melnikova G. F. Innovative Component of Teacher Training in Transformation of Natural Science Education (Chemistry Teachers) [electronic resource] / G. F. Melnikova, S. I. Gilmanshina, R. N. Sagitova // Modern Problems of Science and Education. - 2017. – № 5 – URL: http://www.science-education.ru/ru/article/view?id=26854 (accessed: 30.10.2017) (0,3).

1. Melnikova G. F. From History of Discovery of Element No. 44 at Kazan University / G. F. Melnikova // Chemistry at School. – 2017. – № 5. (0.75 printed sheets (p.s.))

3. Melnikova G. F. Museums of University as Factor of Multicultural Youth Education [Electronic resource] / G. F. Melnikova, S. I. Gilmanshina // Modern Problems of Science and Education. – Kazan, 2015. - №4. URL: http://www.science-education.ru/127-21133 (accessed: 05.08.2015) (0.7 p.s.).

***Monographs:***

4. Melnikova G. F. Nikolay Nikolaevich Zinin. Historical and Biographical Collection / compiled by G.F. Melnikova, A. V. Zakharov, S. I. Gilmanshina. – Kazan: Zhyen, 2016. – 384 p. (23.94 p.s.)

5. Valitova G.F. The Life of A. M. Butlerov. Historical and Biographical Collection / compiled by G.F. Valitova. – Kazan: Zhyen, 2014. – 432 p. (26.94 p.s.)

***Publications in foreign scientific journals:***

6. Melnikova G. F. Multicultural University Education and Museum Pedagogy / G.F. Melnikova, S.I. Gilmanshina // IOP Conf. Series: Materials Science and Engineering. 240 (2017) 012050; http://iopscience.iop.org/article/10.1088/1757-899X/240/1/012050 (Published online: 28 September 2017). (0.50 p.s.).

7. Melnikova G.F. Innovative Teacher Training: Pedagogical Conditions Of Training Technologies For Early Professional Self-Determination / S.I. Gilmanshina, G.F. Melnikova, G.R. Eremeeva // The European Proceedings of Social & Behavioural Sciences EpSBS, 2017. – Vol. XXIX. – P. 232–239 (31 August 2017). (0.80 p.s.).

8. Melnikov G. F. Training of chemistry teachers for sustainable development / S.I. Gilmanshina, R.N. Sagitova, G. F. Melnikova , R. R. Gilmanshina // IOP Conf. Series: Materials Science and Engineering. 240 (2017). 012024; http://iopscience.iop.org/article/10.1088/1757-899X/240/1/012024 (Published online: 28 September 2017). (0.45 p.s.).

9. Valitova G.F. Professional Thinking Formation Features of Prospective Natural Science Teachers Relying on the Competence-Based Approach / S.I. Gilmanshina, R.N. Sagitova, S.S. Kosmodemyanskaya, F.D. Khalikova, N.G. Shchaveleva, G.F. Valitova, N.S. Motorygina // Review of European Studies. – 2015. – Vol 7. – No 3. – P. 341–349 (1.2 p.s.).

10. Valitova G.F. Case technology in the active learning of chemistry future teachers / S. I. Gilmanshina, V. S. Burlakova, G. F. Valitova // Sviridov Readings 2015: 7th International

Conference on Chemistry and Chemical Education, Minsk, Belarus, 7-11 April, 2015: Book of Abstr. – Minsk: Krasico-Print, 2015. – S. 152-153 (0.20 p.s.).

11. Valitova G.F. Museum pedagogy and school chemistry education / G.F. Valitova, S.I. Gilmanshina // Chemija Mokykloje – 2013 (Chemistry in school – 2013), 28 March 2013. – Kaunas: Kaunas University of Technology, 2013. – P. 20–23 (0.44 p.s.).

12. Valitova G.F. Educational potential biographical information when teaching chemistry / G.F. Valitova, S.I. Gilmanshina // Chemija Mokykloje – 2013 (Chemistry in school – 2013), 28 March 2013. – Kaunas: Kaunas University of Technology, 2013. P. 24-26 (0.35 p. s.).

***Publications in other scientific journals:***

13. Melnikova G. F. History of Formation of Kazan Chemical School / G. F. Melnikova // Chemistry for Schoolchildren. – M., 2017. - № 1. – P. 3-10 (0.8 p.s.)

14. Melnikova G. F. Vladimir Vasil'yevich Markovnikov – Head of Moscow Chemists // G. F. Melnikova // Chemistry for Schoolchildren. – M., 2017. - № 2. – P. 3-10 (0.8 p.s.)

15. Melnikova G. F. Through Difficulties To Stars // G. F. Melnikova // Chemistry for Schoolchildren. – M., 2017. - № 3. – P. 3-10 (0.8 p.s.)

16. Melnikova G. F. Education of Students of the Federal University for Sustainable Development of Society / S. I. Gilmanshina, R. N. Sagitova, I. R. Gilmanshin, G. F. Melnikova // Fundamental and Applied Problems of Obtaining New Materials: Research, Innovations and Technologies: proceedings of the 11th International Scientific and Practical Conference. –Astrakhan, 2017. – P. 90-95 (0.50 p. s.).

17. Melnikova G. F. The Cradle of Organic Chemistry. / G. F. Melnikova, F. D. Khalikova// Magarif Journal. - Kazan, 2017. – № 9. – P. 90-93 (0.30 p.s.).

18. Melnikova G. F. Two-Level Training of Chemistry Teachers within Education Transformation / S. I. Gilmanshina, G. F. Melnikova, R. N. Sagitova // Methods of Teaching Chemical and Environmental Disciplines: collected papers of the 9th International Scientific and Methodological Conference, 16-17 November 2017, Brest (Republic of Belarus). – Brest: Brest State Technical University, 2017. – P. 56-59 (0.45 p. s.).

19. Melnikova G. F. First Chemical Laboratory of Kazan University / G. F. Melnikova // History of Laboratories: Theory, Practice, Educational Activity: proceedings of the international science conferences. – M., 2017. – P. 80-82 (0.40 p.s.).

20. Melnikova G. F. Museum as Educational Environment for Students / G. F. Melnikova, A. R. Zinnurova // Actual Problems of Chemical and Ecological Education: the 63rd All-Russian Scientific and Practical Conference of Chemists with participation of international specialists. – SPb., 2016. – P. 253-258 (0.5 p.s.).

21. Melnikova G. F. G. Kh. Kamay – First Tatar Chemical Scientist / G. F. Melnikova // Tatarica. - 2016. – №6. – P. 210-218 (1.0 p.s.).

22. Melnikova G. F. Personnel Crisis of Highly Qualified Specialists as a Key Problem of the Chemical Industry of RT / G. F. Melnikova, G. D. Shaekhova // Higher Education for the 21st century: reports and proceedings of the 13rd International Scientific Conference. - 2016. – Part 3. – P. 42-45 (0,30 p.s.).

23. Melnikova G. F. System of optional courses disciplines for the training of bachelors of the Pedagogical Education line with the area of expertise in chemistry at Kazan Federal University / G. F. Melnikova // Methods of Teaching Chemical and Environmental Disciplines: collection of scientific articles of the International Conference, Brest (Republic of Belarus). – Brest: Brest State Technological University, - 2015. – P. 111-113 (0.40 p.s.).

24. Valitova G.F. Case technology as a factor of practical orientation for the training of bachelors, i.e. future teachers of chemistry // S. I. Gilmanshina, Valitova G. F. Burlakova V. S. // Actual Problems of Chemical and Ecological Education: Collected scientific efforts of the 62nd All-Russian Scientific and Practical Conference of Chemists with participation of international specialists, 15-18 April 2015. S-Pb.: Publishing house of Herzen Russian State Pedagogical University, 2015. – Pp. 220-222 (0.30).

25. Valitova G.F. Development of Higher Chemical Education, its Correlation with Social and Economic Needs of the Region / G. F. Valitova // Innovations in Teaching Chemistry: collected scientific and methodical works of the 5th International Scientific and Practical Conference. – Kazan: Kazan University publishing house, 2014. – P. 195-202 (0,8 p.s.).

26. Valitova G.F. Fundamental Chemical Education as Key Factor in Success of Modern Teacher of Chemistry / G. F. Valitova, S. I. Gilmanshina // Methods of Teaching Chemical and Environmental Disciplines: collected scientific articles of the International Scientific and Methodological Conference, Brest (Republic of Belarus). – Brest: Brest State Technical University, 2014. – P. 37–39 (0.30 p. s.).

27. Valitova G.F. Historical Background of Formation of Chemical Education in the Kazan Province in the Pre-Revolutionary Period / G. F. Valitova // Innovations in Teaching Chemistry: collected scientific and methodical works of the 5th International Scientific and Practical Conference. – Kazan: Kazan University publishing house, 2014. – P. 202-209 (0,6 p.s.).

28. Valitova G.F. Role of Higher Educational Institutions Museums in the Multicultural Education of Youth / G. F. Valitova, S. I. Gilmanshina // Multicultural Educational System of the Volga Region: Integration of Regional and International Experience: collected scientific efforts of the 2nd International Scientific and Practical Conference, 30 October 2014, Kazan. Kazan: Otechestvo, 2014. P. 119-124 (0.5 p.s.).