ISSN 1070-3632, Russian Journal of General Chemistry, 2013, Vol. 83, No. 3, pp. 577–585. © Pleiades Publishing, Ltd., 2013.
Original Russian Text © V.N. Khvalyuk, E.I. Vasilevskaya, 2011, published in Rossiiskii Khimicheskii Zhurnal, 2011, Vol. 55, No. 4, pp. 73–80.

Higher Education in Chemistry in the Republic of Belarus

V. N. Khvalyuk and E. I. Vasilevskaya

Belarusian State University, pr. Nezavisimosti 4, Minsk, 220030 Belarus
e-mail: khvalyuk@bsu.by

Received September 3, 2011

DOI: 10.1134/S1070363213030304

On July 11, 2007, a new Law on Higher Education was accepted in the Republic of Belarus. The necessity of this measure was quite obvious and predictable, as recently the system of higher education in our country was developing very rapidly. As of the beginning of the academic year 2011 there were 55 institutions of higher education registered in Belarus, including 45 public (82%) and 10 private institutions (18%). The state higher educational institutions were represented by 31 universities, 7 academies, 3 institutes, and 4 higher colleges.

The number of students attending the higher educational institutions of Belarus has increased almost 1.5-fold over the last decade.

There is a clear trend towards an increase in the number of students willing to receive higher education at their own expense. Thus, for the last decade the number of state-paid students has risen by less than 1% (from 32 884 to 33 138), whereas the number of fee-paying students has almost doubled (from 37 227 to 65 679). In the academic year 2010/2011 60 093 students studied in private higher educational institutions, which accounts for 13.6% of the total number of students, including 15 437 (26%) of full-time and 44 656 (74%) of distance learning students.

Distribution of students of public higher educational institutions according to forms of attendance in the academic year 2010/2011 was as follows: 48 757 – full-time students, 143 – part-time (evening) students, and 38 514 – distance learning students. It can be seen that distance learning students account for almost a half (46%) of all students of public higher educational institutions.

Students who pursue higher education in chemistry account for a very small part of the entrants, students, and graduates of higher educational institutions; they can be found in two areas of specialization: natural sciences and equipment and technology (Table 1).

As could be expected, the overwhelming majority of the entrants, students, and graduates of private higher educational institutions wish to administer justice, manage the economy, or govern one and all. The pronounced social character of the motivation for training is confirmed by the results of a survey among the students of Belarusian State University (BSU). When selecting a higher educational institution and specialty, about 40% of the students were attracted by the status of the university, whereas 0.3% and 0.5% of the respondents indicated their abilities to natural sciences and humanities, respectively [2]. The factor of BSU prestige also remains significant for first-year students in 2005–2007; however, in 2007 the number of first-year students who think that it is possible to get an interesting specialty at BSU is already as high as 53.2%; 59.7% of the students emphasize a high level of teaching (Table 2).

According to Article 7 of the new Law on Higher Education, the general requirements to the educational level, the duration of training, the graduates' level of knowledge, the compulsory minimum content of higher education, and a number of other related issues have to be specified in state standards of higher education. This was the starting point for development of the standard for the specialty 1-31 05 01 "Chemistry (with reference to areas)."

At present, there are three models of organizing higher education in chemistry implemented worldwide, regulating the content of education: at the national level using state standards (Russian Federation, Ukraine, Kazakhstan, Poland, and Belarus); within the framework of a unified syllabus, which is the same for one specialty in different higher educational

Table 1. Distribution of students of public and private higher educational institutions (marked "*") in the Republic of Belarus according to areas of specialization (as of the beginning of the academic year 2010/11)

Specialization	Admitted	Studied	Graduated
Architecture and construction	4827	19063	2382
Health protection	4328	19646	2492
Public catering	175	799	164
Humanities	3352 256*	16327 1184*	2691 194*
Communication, law, economics, management	27694 12323*	123930 56633*	21068 9201*
Art and design	1404 178*	6490 1039*	1104 101*
Pedagogics	9929	47455	11069
Pedagogics. Professional training	852 0*	3381 0*	625 38*
Natural sciences	3071 0*	13240 222*	2250 12*
Social protection	682	3759	568
Agriculture and forestry	6411	27828	4651
Security service	1916	7405	1288
Equipment and technology	19838 353*	81903 1015*	12022 67*
Physical training. Tourism	2216	8169	894
Environmental science	719	3402	457
TOTAL	87414	382797	63725

Table 2. Answers of first-year students of Belarusian State University about why they have entered BSU [3]

Answer	2005	2006	2007
It is a prestigious institution of higher education	44.0%	42.2%	54.4%
It has a high level of teaching	55.6%	53.9%	59.7%
It was recommended by acquaintances, friends, or relatives	6.1%	7.3%	9.8%
Here it is possible to get a specialty that is interesting for me	48.0%	38.3%	53.2%
The university diploma makes it possible to make a career, get a good position	41.2%	32.6%	44.5%
Another answer	4.5%	2.9%	5.7%

institutions of the country (Germany etc.); and using programs of training developed directly by higher educational institutions (Bulgaria, Lithuania, Latvia etc.). In this case, the national standards regulate and secure qualification and common cultural requirements to higher educational institution graduates of a certain specialty regardless of the higher educational institution type and location.

Obligatory conditions for standardization of education are, first, compliance of the national standards with the generally accepted international norms and,

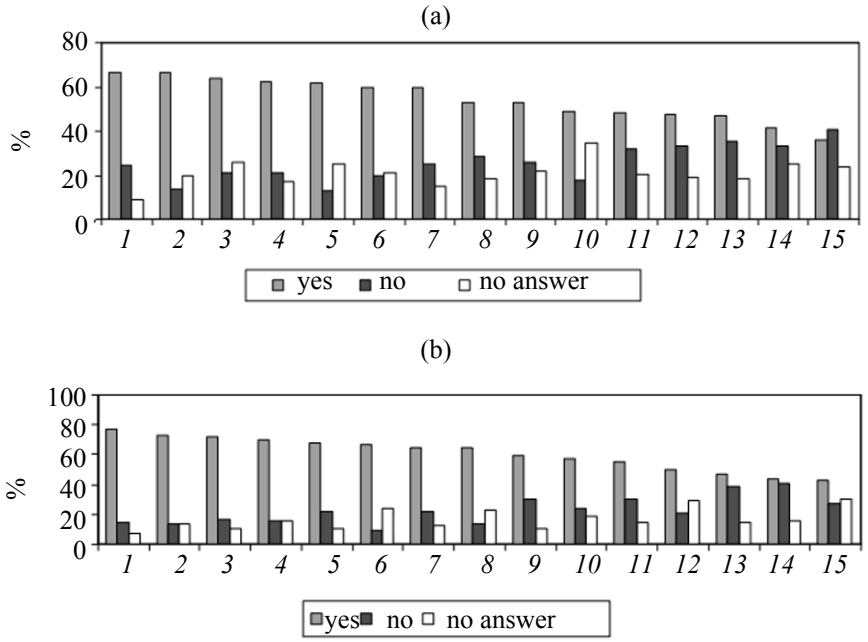

Fig. 1. Results of sociological survey among Belarusian State University students (2007). (a) Satisfied with the content of educational courses: (*1*) faculty of philosophy and social sciences, (*2*) faculty of philology, (*3*) faculty of biology, (*4*) faculty of physics, (*5*) faculty of chemistry, (*6*) faculty of economics, (*7*) faculty of law, (*8*) faculty of radiophysics and computer technologies, (*9*) faculty of humanities, (*10*) State Institute of management and social technologies; (*11*) faculty of applied mathematics and informatics, (*12*) faculty of international relations, (*13*) faculty of history, (*14*) faculty of mechanics and mathematics, (*15*) faculty of geography. (b) Satisfied with the forms and methods of training: (*1*) State Institute of management and social technologies, (*2*) faculty of biology, (*3*) faculty of philology, (*4*) faculty of physics, (*5*) faculty of humanities, (*6*) faculty of philosophy and social sciences, (*7*) faculty of mechanics and mathematics, (*8*) faculty of law, (*9*) faculty of radiophysics and computer technologies, (*10*) faculty of chemistry, (*11*) faculty of applied mathematics and informatics, (*12*) faculty of economics, (*13*) faculty of history, (*14*) faculty of geography, (*15*) faculty of international relations.

second, strict adherence to the standards throughout the entire specified period by all concerned. Only in this case an educational standard becomes an education quality standard, in addition, reflecting the obligations of the state to ensure achievement of the corresponding educational level by its citizens.

According to many specialists, a specific feature of educational standards is the idea of minimal sufficiency incorporated in them. To comply with the standard is to meet the minimal requirements ensuring satisfactory quality of the learning results. As noted in work [4], the requirement of minimality in educational standards is a fundamental difference between them and, for example, standardization of industrial objects; as such standards are based on the requirement of maximality.

On the one hand, the standard of a higher educational level has to rely on the corresponding documents of the lower educational level; on the other hand, it has to contribute to further deepening and broadening of knowledge. Thus, the current standard of higher education in force in the Republic of Belarus for the specialty "Chemistry" contains requirements to the educational level of applicants and the composition of entrance tests [5], which ensures continuity in the study of chemistry in the transition from school to university.

In September, 2007, a sociological survey was carried out among the second- and fourth-year students from 15 faculties of Belarusian State University. Along with many other questions, the students were asked whether they were generally satisfied with the following, most significant qualitative aspects of the educational process. The students' answers concerning two aspects of the educational process, namely, the content of educational courses and the forms and methods of training, are given below (Fig. 1).

As follows from the above data, a little more than 60% of the chemical faculty students are satisfied with the content of education, whereas the number of

Table 3. Recommended distribution of study time in standard curriculum

Blocks of disciplines	Relative volume of classroom training	Distribution of study time		
		into the compulsory component	into elective disciplines and courses	into the university component
I. Social science and humanity disciplines	14–16%	85–90%	10–15%	–
II. Natural science disciplines	6–30%	60–70%	25–30%	10–15%
III. General and special professional disciplines	45–65%	60–70%	20–25%	10–15%
IV. Specialization disciplines	10–15%	–	–	–

Table 4. Training duration with regard to different types of training activities

Types of training activities within the curriculum	Duration of training, weeks
Theoretical training	147
Examination sessions	35
Practical training	16
Thesis preparation	9
Final state certification	4
Student vacation (including 4 weeks of post-thesis vacation)	44
Total	255

unsatisfied and undecided is almost 40%, which is a lot. Answers to the question regarding the students' satisfaction with the forms and methods of training divided more or less similarly. The students' dissatisfaction is largely related to the fact that university laboratories and workshop rooms are poorly fitted out with modern equipment and reagents. In such situation chemistry loses its appeal as an experimental science, which largely determines the choice of a future specialty made by secondary school graduates. It was necessary to take it into consideration when developing a new standard. Apart from that, when starting to develop this new standard, we were guided by the necessity to significantly enhance the role of students' independent work as one of the most important factors for improving the quality of education in higher educational institutions. Acquisition of skills for independent work and experience in creative use of the acquired knowledge can be considered one of the key outcomes of training in a higher educational institution.

The development of the standard (2007) was performed in compliance with recommendations of the Belarusian Ministry of Education and the Republican Institute of Higher School, presented in the form of a layout for the standard [6]. The full cycle of theoretical training should consist of four blocks of disciplines. Table 3 shows the recommended time ratio between the blocks of subjects and the internal distribution of study time in a typical curriculum.

It should be noted that it was not possible to fully comply with the recommended time distribution into blocks and sections for all areas of the specialty "Chemistry." Otherwise, it would result in unjustified restructuring of the existing process of training specialists in chemistry in certain areas. The discussion of this problem with colleagues and the accumulated experience of organizing the educational process at the chemical faculty demonstrated that such changes could lead to deterioration of the quality of education. Therefore, we did our best to follow the given recommendations in the developed structure; in cases when it was impossible we tried to justify the deviations.

According to the new educational standard, the total duration of training in higher educational institutions is 5 years (255 weeks). Distribution of time for different types of training activities is given in Table 4.

Table 5. Standard curriculum structure for speciality "Chemistry"

Blocks of dis	Work volume, h			Credits
	total	classroom training	independent work	
I. Social sciences and humanities	1568[a]	744 (15.4%)	348	42
I.1.Compulsory component	1416[a]	642	298	36
I.2. Elective subjects	152	52	50	6
II. Natural sciences	1546	1042 (21.7%)	504	61
II.1. Compulsory component	954	654	300	38
II.2. University component	400	286	114	17
II.3. Elective subjects	192	102	90	6
III. General and special professional disciplines	3650	2298 (47.6%)	1352	130
III.1. Compulsory component	2470	1564	906	93
III.2. University component	772	476	296	28
III.3. Elective subjects	408	258	150	9
IV. Specialization disciplines	1124	740 (15.3%)	384	39
Total	7888[a]	4824	2588	272

[a] Including 476 h of physical training and sports.

The final state certification includes passage of the state examination to the State Examination Commission and the thesis defense.

The first block (social science and humanity disciplines), the structure and scope of which are determined in a separate educational standard of the Republic of Belarus [7], includes the following subjects: history of Belarus, basics of the Belarusian state ideology, philosophy, sociology, pedagogics, psychology, foreign language, and physical training and sports. For higher educational institutions variability of this cycle is reduced to the possibility of specifying optional disciplines; there have to be three optional courses during a five-year educational period (with the total volume of 152 academic hours including 50 h of the classroom load).

The structure of the curriculum for the area of specialization 1-31 05 01-01 "Chemistry (scientific and production activity)" is given in Table 5 as an example. For this specialty it was possible to maintain the recommended classroom load ratio both between the blocks of disciplines and between the sections inside the block.

The compulsory component of the second block (natural sciences) includes higher mathematics, physics, basics of information technologies, basics of ecology and energy-saving, and some other subjects. The core disciplines of the university component of this block are information technologies in chemistry, foreign language (in addition to the first block), mathematical modeling of chemical processes, and history of chemistry.

The compulsory component of the third block (general and special professional disciplines) includes a traditional set of courses: inorganic, analytical, organic, and physical chemistry, chemistry of high-molecular compounds, crystal chemistry, and general chemical technology. This block also includes certain prescriptive courses, such as occupational safety and basics of intellectual property management. The university component of this block is formed by the following equally traditional disciplines: physico-

Table 6. Distribution of training duration with regard to types of training for speciality "Chemistry"

Types of training	Work volume, h			Credits
	total	classroom training	independent work	
Theoretical training	7888[a]	4824	2588	283
Examination sessions	1890		1890	42
Optional subjects	50	36	14	–
Sub-Total	9828[a]	4860	4462	314
Practical training, 16 weeks	864		864	24
Thesis preparation, 9 weeks	486		486	14
Final state certification, 4 weeks	216		216	6
Total	11394[a]	4860	6058	358

[a] Including 476 h of physical training and sports.

chemical methods of analysis, physical methods of research, quantum chemistry and molecular structure, structure of matter, and fundamental problems of chemistry.

Apart from theoretical training (lectures, laboratory and practical classes), the educational process includes examination sessions, elective courses, practical training, development of the thesis, and the final state certification. Duration of these types of training for the specialty "Chemistry" is given in Table 6.

During a 5-year period of study in the course of examination sessions (35 weeks) students have to pass 39 examinations and 43 tests and to prepare 5 courseworks. The educational process includes 2 weeks of curricular, 6 weeks of practical, and 8 weeks of pre-graduation training (16 weeks in total). A period of 9 weeks in the tenth term is allocated to students for development of their thesis; the state examination in the specialty, area of specialty, and specialization, as well as the thesis defense in the presence of the State Examination Commission is also envisaged.

In the Republic of Belarus training in the specialty 1-31 05 01 "Chemistry" is performed only at the chemical faculty of Belarusian State University and partially at the biological faculty of Mogilev State University. Within the framework of this specialty BSU trains specialists in four areas, which are scientific and production activities, scientific and teaching activities, pharmaceutical activities, and environmental protection. The curricula for these areas are absolutely the same with regard to the compulsory components of the first, second, and third blocks of disciplines. The differences are in the university component, elective disciplines from the second and third block, and specialization disciplines.

In compliance with the new educational standard there is a great classroom load as compared to foreign institutions of higher education, which amounts to the average of 33 academic hours per week. Skills for creative independent work have to be acquired by future specialists during classroom training, which requires teachers implementing these new curricula to apply innovative educational technologies and organize the educational process on the basis of the teaching and research principle.

At present, new standard curricula and work plans for all areas of the specialty "Chemistry" have been developed and implemented on the basis of the Belarusian higher educational standard.

It is too early yet to talk about the results of introduction of the new educational standard into the educational process. However, there are already some concerns that the expected positive results can be underestimated. The matter is that undoubtedly the final result of training depends on the level of knowledge of those who come to study in the first course of higher educational institutions, i.e. on the educational level of secondary school graduates, on the efficiency of this member of the educational system. Continuity between different educational levels is one of the most important factors for improving the efficiency of higher education in chemistry.

For the last five years there has been a clear alarming trend towards a reduction in the applicants'

level of knowledge, especially with respect to those who enter the faculty of natural sciences. In our opinion, an important role here is played by the recently institutionalized system of centralized testing (analogous to the Russian Unified State Examination), which since the academic year 2010 has become the sole basis for competitive selection into higher educational institutions of the Republic of Belarus. Within the framework of the above-mentioned survey carried out in September, 2007, first-year students of Belarusian State University were asked a question concerning the form of entrance tests (Fig. 2).

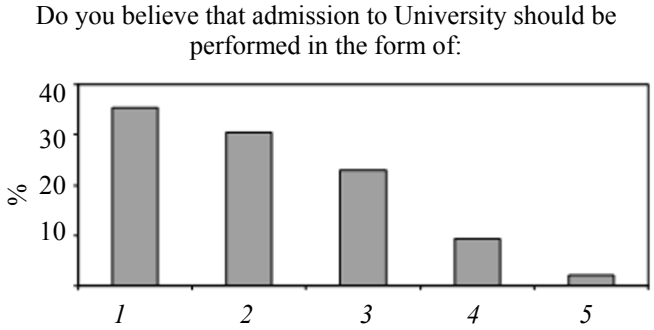

Fig. 2. Answers of first-year students (2008) concerning forms of entrance tests to Belarusian State University. (*1*) Combination of entrance examinations and testing; (*2*) entrance examinations; (*3*) unified testing; (*4*) no answer; (*5*) other.

Almost 2/3 of the respondents believe that an examination in one form or another (either a single examination or an examination in combination with the centralized testing results) is necessary as a criterion for selection of applicants to be admitted to university and only 1/3 consider the results of centralized testing as the sole basis for admission to higher educational institutions. Taking into account that Belarusian State University is the leading and the most prestigious educational institution in the Republic and that for many decades our entrants and students have been represented by the best secondary school graduates of the Republic, this opinion is apparently worth thorough consideration. It should be added that many teachers of the chemical faculty share this point of view on this problem. Hopefully, those who in the course of their work form the state policy for development of higher education in Belarus will not leave this problem unattended.

Unfortunately, at present it is impossible to make objective assessment of the centralized testing impact on the process of natural science education at secondary school. First of all, it is because in Belarus this system itself is very specific, free from any analysis (due to the absence of primary data) and criticism. For example, a general description of the methodology for calculating the testing final score is publicly available [8]; according to this methodology, the final score is calculated taking into account the sum of the answer matrix elements for each column, which is equal to the number of applicants who have performed the proposed task correctly. It is evident that in this case the testing results will depend on the level of knowledge of the selection participants working with this version and the complexity of test questions in this version; therefore, they cannot be compared to the results of the previous years. Then, it is hard to understand the Director of the Republican Institute for Knowledge Control, who in the latest article [9] on the results of the testing 2011 declared that the average score difference in the Belarusian language was 0.26 points, in mathematics – 0.20 points, and in physics – 0.50 points as compared to the

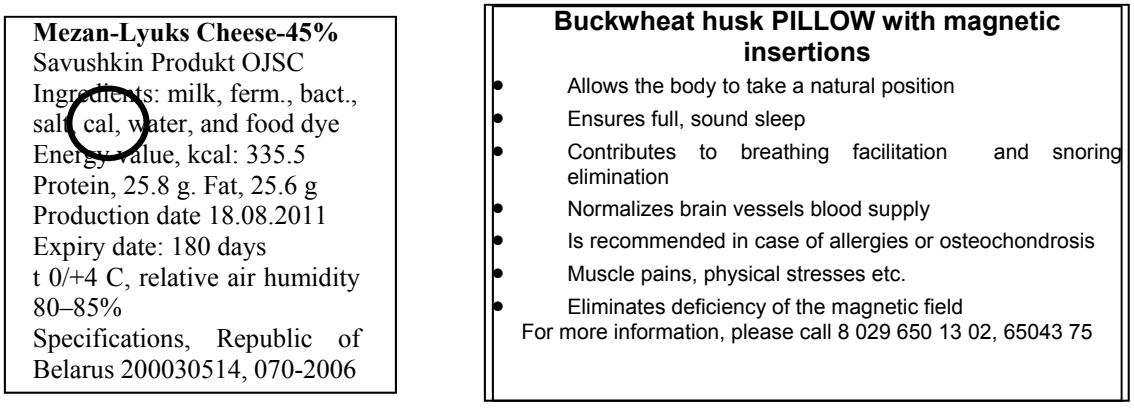

Fig. 3. Examples of illiteracies in product descriptions identified by the authors of the article.

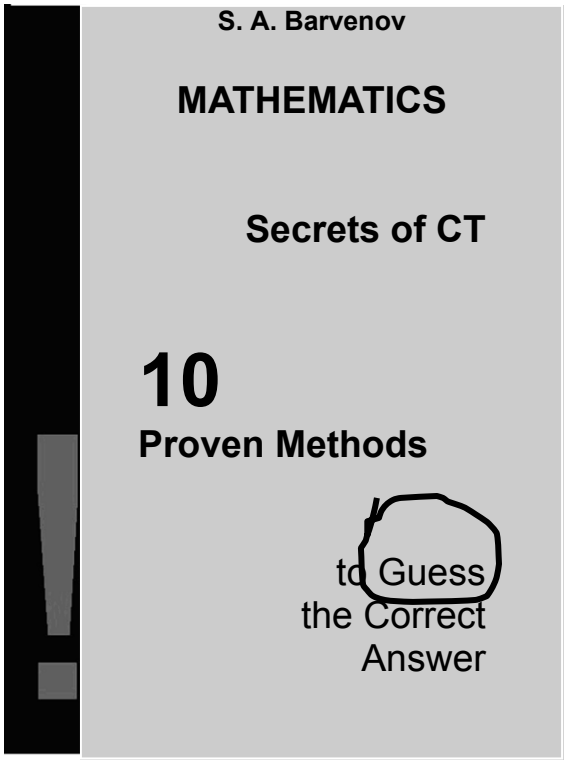

Fig. 4. Methodological guide advertisement [4].

results of 2010. This longed-for stability makes no sense.

It is possible to form a certain general impression of the situation with natural science education on the basis of facts leaking into the press and close observation of the surrounding reality. We believe that several examples given below will allow a literate reader to form a general impression of the corresponding trends, which are, however, characteristic of many countries.

Figure 3 (left) shows a scanned copy of a product label listing the ingredients of cheese, bought in the very center of Minsk in Stolitsa (Capital), a very prestigious shopping center. A sales assistant answered the question about what "cal"[1] in the composition of the product meant saying that it was a new vitamin supplement. Even after a brief discussion explaining to her that in fact it was "calcium chloride" and that it was absolutely inacceptable to abbreviate names of product ingredients in such a way, she held her opinion. The next day cheese was on sale with the same product label.

Another example is an advertisement on the front door of a residential building where one of the authors lives. Among all miraculous properties of the advertised pillow the one that was the most astonishing was its property "to eliminate deficiency of the magnetic field."

It is possible to judge about the attitude of the Ministry of Education to centralized testing itself on the basis of an advertisement of a "methodological guide" found in its official printed medium [10] – Nastavnitskaya Gazeta (Teachers' Newspaper) (Fig. 4). The text accompanying the photograph read as follows, "The present guide offers ten ways using which in the course of centralized testing in mathematics students will be able to choose the correct answer from the proposed options, without having to solve the problem in full." Moreover, the web-site of the Republican Institute for Knowledge Control contains a link to an article titled "Test Questions Suggest Correct Answers" developed by the institution's methodologists in biology [11]. Here is one of the recommendations from this article for successful completion of the test, "Try to guess. If you are not sure about the correct answer but intuitively prefer one option over the others, you should follow your intuition. In this case try to choose an option, which, in your opinion, is the most probable." No doubt it is "a very strong" recommendation in scientific and methodological terms. The leading Western centers for testing have much to learn from our specialists.

As for the content of testing in chemistry, the situation is not much better in this respect. Below we will provide an example of a test question and its answer options from a test developed in the depths of the Republican Institute for Knowledge Control for rehearsal testing in chemistry in Belarus (2006), "Choose the symbol of the chemical element of silicon." The answer options included (a) S; (b) C; (c) Si; and (d) Se. To clarify the situation it should be mentioned that the testee is given the periodic table of chemical elements, where in cell number 14 there is the symbol of silicon and its name in Russian. This question was offered to school graduates who have studied chemistry at secondary school for five years and who have consciously chosen testing in chemistry as a subject required for admission to the corresponding specialty at a higher educational institution.

[1] In the original language the first three letters of the word "calcium" form another word meaning "feces" (*translator's note*).

It was possible to get "classified data" on the results of testing (2008) with respect to another similar question in chemistry. The question read as follows, "How many hydrogen atoms are there in the molecule of ethanol C_2H_5OH?" The applicants had to choose the correct answer from the following options: (a) 1; (b) 5; (c) 6; and (d) 7. Now then only 78.59% of the applicants who had consciously chosen testing in chemistry gave the right answer. For your reference, it is necessary to pass testing in chemistry for admission to chemical specialties and medical institutions of higher education. As of the beginning of the academic year 2010/11 in Belarus 952,682 school children studied at 3584 public and 9 private schools, including 75,603 in the eleventh (final) year. In 2011 15,832 school graduates chose centralized testing in chemistry. Apparently, the test was successfully passed by those who had thoroughly learnt the recommendations of the methodologists in biology from the above-mentioned book "10 Proven Methods to Guess the Correct Answer." Otherwise, it is simply impossible to imagine the results of studying chemistry for five years and the desire to continue education in the sphere where further training in chemistry is required.

All of the above leads to the conclusion that any modernization of higher education should start at secondary school. Genetic continuity of different educational levels will not allow implementation of even the most innovative ideas in respect of higher education without taking into account the real situation at secondary school. As at present the situation with school education in chemistry can by no means be considered satisfactory, there is no point in expecting a significant improvement in the quality of higher education in chemistry in the foreseeable future.

Another very powerful argument for increased attention to school and university education in chemistry should be a planned large-scale project of constructing the Belarusian nuclear power plant. September, 2011, can be considered the actual start of the project, as the documents approving the Ostrovets site (Grodno region) for location of the Belarusian nuclear power plant were signed at that time. We would like to believe in bright "nuclear future" of Belarus; however, the sad experience of Chernobyl and the more recent experience of Fukushima give no grounds for that.

REFERENCES

1. *http://www.giac.unibel.by/ru/sm.aspx?guid=10503; http://www.giac.unibel.by/ru/sm.aspx?guid=10563.*
2. Kharchenko, A.V., *Uchebnoe znanie kak osnova porozhdeniya kul'turnykh form v universitetskom obrazovanii* (Educational Knowledge as the Basis for Generation of Cultural Forms in University Education), Minsk, 2001, pp. 157–161.
3. *Sociological Survey of First-Year Students, Universitet*, nos. 15–16 (1966–1977), October 17, 2007.
4. Bratsennikava, A.M., *Nar. asveta*, 1999, no. 6, pp. 67–72; no. 7, pp. 36–42.
5. RD RB 02100.5.039-98, *Educational Standard, Higher Education, Specialty N.03.01.00 Chemistry*, Minsk: Ministerstvo Obrazovaniya RB.
6. *Layout of First Level Higher Educational Standard of the Republic of Belarus*, Minsk: MO, 2007.
7. RD RB 02100.5.227-2006 *Educational Standard, Higher Education, First Level, Cycle of Social Science and Humanity Disciplines.*
8. *http://www.rikz.unibel.by/ru/testing/info/metotdika.rar.*
9. *Nastavnitskaya Gazeta* (Teachers' Newspaper), August 25, 2011.
10. *Nastavnitskaya Gazeta* (Teachers' Newspaper), July 9, 2009.
11. *http://www.rikz.unibel.by/ru/testing/articles/Questions of Test Offer The Correct Answers. doc.*