

Efficiency of the Methods for Forming the Chemical Safety Competence of Future Doctors

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Abstract: The paper provides a theoretically substantiated scope, structure, criteria and indices of the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry. There is a motivation-value component (formedness of steady inner drives and understanding of the practical value of interpreting and applying biochemical aspects of chemical safety to the medical and preventative activities of future doctors), a cognitive component (knowing the substantive aspects – ‘Modern Chemical Safety Ideas’ and ‘Biochemical Aspects of Chemical Safety’) and an activity component (using the chemical safety knowledge, capabilities and skills) to be singled out in the structure of the chemical safety competence of future doctors. There are set requirements to the indices and levels (low, average, adequate, high) of the formedness of the motivation-value, cognitive and activity criteria of the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry.

The article describes the methods of forming the competence of future doctors in chemical safety during the study of bioorganic and biological chemistry, suggests the use of modern teaching methods (designing, solving situational tasks, performing laboratory studies simulating the effects of harmful chemicals, testing), pedagogical methods (interpretation of the concepts of biochemical trends of chemical safety, video lectures and methodical instructions are provided for independent study by students), work in groups and individual work.

Keywords: *Medical education; professional training of doctors; studying biological and bioorganic chemistry; chemical safety; safety alert symbols; markings of chemical substances.*

How to cite: Ishchenko, A., Stuchynska, N., & Tolmachova, V. (2022). Efficiency of the Methods for Forming the Chemical Safety Competence of Future Doctors. *Revista Românească pentru Educație Multidimensională*, 14(4), 131-144. <https://doi.org/10.18662/rrem/14.4/633>

Introduction

Professional training of medical specialists in the aspect of today's needs is the main priority of educational policy. Medical education is implemented as an aspect of the competence principle based on effective educational technologies (Burger et al., 2003; Reibnegger et al., 2008). The paper contains several substantiated approaches to the content and list of general and professional competences of a future medic. The author presents the experience in reforming the medical education that calls for updating the curriculum content, combining the theoretical and clinical training of future doctors, an integrated studying of educational materials, a group work of students, using the problem-based learning and interactive technologies (Hamouda et al., 2019; Ischenko, 2021; Nizhenkovska et al., 2020; Reva et al., 2020; Voskoboinikova et al., 2019). The particularities of the preparations for composing and assessing the license exam 'Krok 1' (Step 1) (Donnon et al., 2007; Johnson et al., 2014) are studied. The author explains the structure of a future doctor's professional competence in the context of the diagnostic, clinical and pre-emptive components formedness (Filonenko, 2016).

International security is the main principle and factor of globalization in the world. Thus, in the conditions of world conflicts, which are actively exploding in the 21st century, it has become obvious to humanity that a few wrong steps and the world can disappear (Corbin, 2017). The most dangerous are chemical and biological weapons that can be used against humanity.

Such a danger creates a worldwide need to improve the effectiveness of methods of forming the competence of future doctors in chemical safety (Ortmann & Waller, 2005). It is obvious that the exceptional natural and scientific training of specialists who consciously decided to obtain a higher chemical education and subsequently master educational programs of higher professional education in areas and specialties of the chemical profile will allow to obtain highly competent and competitive young specialists who are necessary for modernized industrial production and who can professionally take care of safety (Patterson et al., 2016). Such specialists are a necessity for the modern globalized world.

The author studies the pedagogical environment of the formation of professional competences of future doctors during the natural-scientific training that call for expanding the professional space, actualising the

professional potency of the natural-scientific training, tenors of the learning and cognitive and scientific activities of students (Makarenko, 2017).

The article reveals insights into the specifics of entrenching the integrated system of natural-scientific and professional-practical training of medics as an integral component of the formation of integral, general and professional competences (Paikush, 2018; Stuchynska et al., 2021).

The application of interactive methodical practices for digesting general and professional competences in studying medical subjects (Gune et al., 2018; Maloney et al., 2013; Radojicic et al., 2018) and bioorganic and biological chemistry at medical higher educational institutions is analysed (Gerush et al., 2016; Kniazieva, 2014).

The problem regarding the course 'Biological and Bioorganic Chemistry' studied by students of the medical-psychological faculty (Nizhenkovska et al., 2012), passing the license integrated exam 'Krok 1. (Step 1). General Medical Training' (Gaiova et al., 2017), formation of all-objective competences in the course of teaching biochemistry (Shmygol, 2013) is studied.

The author analyses the particularities of the formation of practical skills of medical faculty students in the course of biological and bioorganic chemistry (Tokaryk, 2016). However, the problem of future doctors' learning modern approaches to safety alert symbols, handling chemical substances, responding to a chemical hazard remains open. The compulsory student course 'Biological and Bioorganic Chemistry' makes it possible to integrate the modern aspects of chemical safety with the study of biochemical mechanisms of the effect of toxic agents (Ishchenko, 2017).

The objective of this paper is to substantiate theoretically the methods and techniques for forming chemical safety competences of future doctors in the course of studying bioorganic and biological chemistry.

Scope, structure of the chemical safety competence of future doctors in the course of studying biological and bioorganic chemistry, indices and requirements to their formedness levels

This papers studies the chemical safety competence of a future doctor as an integral feature of the personality that reflects the preparedness to collect, to analyse, to interpret the present data of biochemical mechanisms of the effect of chemical substances on the human's health and to use the acquired knowledge, skills and capacities for the safe handling of

chemical compounds in the life cycle in order to perform successful medical and preventive activities.

The structure of the chemical safety competence of a future doctor has three components identified: motivation-value, cognitive, activity components (Fig. 1).

The criteria are set (motivation-value, cognitive, activity), the indices and requirements to its formedness levels (low, average, adequate, high) are devised for assessing the level of formedness of the chemical safety competence.

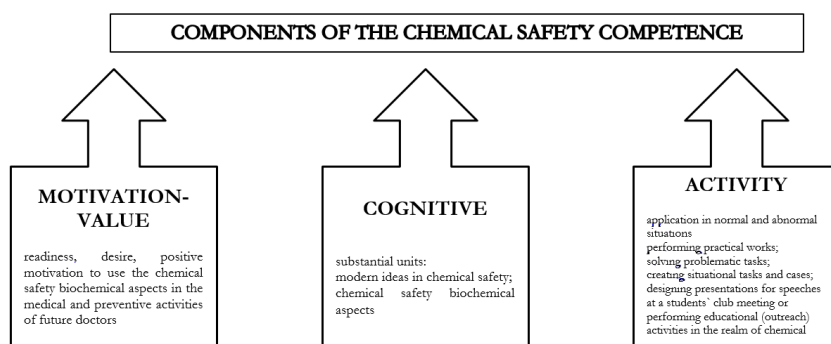


Fig. 1. Structure of the chemical safety competence of a future doctor in the course of studying biological and bioorganic chemistry (designed by the authors)

The formedness indices of the chemical safety competence according to the motivation-value criterion comprise: a future doctor's motivation to study bioorganic and biological chemistry; a student's aspiration to work independently; students' readiness and desire to use the chemical safety knowledge, skills and capacities in the course 'Biological and Bioorganic Chemistry'; a doctor's aiming for resolving chemical safety problems in the future profession. The scope of formedness levels of the motivation-value component of the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry is presented according to the indices: low – no motivation to study the subject and to work independently; a student is not aiming for using the chemical safety knowledge, skills and capacities in the future profession; average – available extrinsic motives to study the subject and to work independently, no systematic activities in completing the tasks for using the chemical safety knowledge, skills and capacities; adequate – available unstable intrinsic motives to study bioorganic and biological chemistry; a student

systematically completes chemical safety tasks, but the formal interest prevails having a purpose to get a good mark; high – available stable intrinsic motives to study the course ‘Biological and Bioorganic Chemistry’; a student understands the practical value of using the chemical safety knowledge, skills and capacities in his/her further pre-emptive activities.

The indices of formedness of the chemical safety competence of a student under the cognitive criterion is a level of the knowledge digested about modern components and biochemical aspects of chemical safety singled out in the scope of the cognitive component. The scope of the levels of formedness of the cognitive component of chemical safety competence of future doctors in the course of studying bioorganic and biochemical chemistry is presented as follows according to the indices: low – partial learning of the studying material, unsystematised knowledge; average – partial learning of the studying material components, but a student cannot trace cause-effect relationships, compare, analyse information; adequate – knowing the studying material, using the knowledge in normal situations; high – systemic, strong, completely formed knowledge, skills, capacities, wise use of materials in normal and abnormal situations.

The activity criterion of the chemical safety competence allows for a future doctor’s applying the knowledge, skills and capacities in the field of chemical safety for solving a problematic task by a set algorithm or by the creative endeavour. The scope of the levels of formedness of the activity criterion of the chemical safety competence in the course of studying bioorganic and biological chemistry is as follows: low – a student cannot use the knowledge, skills and capacities in the field of chemical safety for solving problematic tasks; average – a student completes practical tasks by the pre-set algorithm, makes mistakes; adequate – a student uses the knowledge, skills and capacities in the field of chemical safety for solving practical tasks, substantiates his/her actions, draws conclusions; high – a student substantiates the action plan, creatively solves problematic tasks.

Methods and techniques for forming the chemical safety competence of future doctors in the course of studying biological and bioorganic chemistry

The methods and techniques that provide for the implementation of three stages in order to form the chemical safety competence of future doctors were devised for forming the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry.

The initial stage was carried out in the first year in the course of studying extensive Module 1. 'Biologically Important Bioorganic Compounds Classes. Biopolymers and Their Structural Components' configured with the actualisation of the knowledge of chemistry obtained at school. In view of this fact, the following was studied and analysed at the first lesson during the safety briefing while completing practical works:

- modern approaches to safety alert symbols and marked chemicals (hazard types and classification; pictograms that indicate physical hazards, hazards to human health and environment; signal words; short hazard description; safety precautions) (Ishchenko et al., 2015);

- warning colours and safety symbol groups that place the emphasis on immediate hazards, warn about a possible danger, set action plans and give the green light for certain actions to ensure information and safety (Ishchenko et al., 2015);

- safety cards of inorganic and organic compounds used as reagents in laboratory tests with the warning marking and safety signs indicated (Ishchenko et al., 2015);

- terms in the field of chemical safety and toxicological characteristics (Ishchenko et al., 2015).

At the main stage in the course of studying the information of the extensive module 'Biologically Important Bioorganic Compounds Classes. Biopolymers and Their Structural Components', the first-year students analysed the safety cards of chemical compounds: an intermediate product of metabolic processes (pyruvate, lactate, oxaloacetate, acetone, β -hydroxybutyric acid), endogenous toxins that occur in the human body (skatole, indole, phenol); medicines (salicylic acid, acetylsalicylic acid, salol).

In the second year of study, future doctors studied the learning material of the comprehensive modules 'General Principles of Metabolism' and 'Molecular Biology. Biochemistry of Cell-Cell Communications', where they studied biochemical aspects of chemical safety: mechanisms of inhibition of enzymatic reactions by toxic agents; inhibitors and disconnectors of oxidative phosphorylation; molecular mechanisms of the effect of toxic agents; creation and treatment of endogenous toxins; biotransformation of xenobiotics.

In the practical classes, special attention was paid to the following when studying the aforesaid aspects:

- analysis of the scope of terms and answers to tests of the corpus of the medical program 'Krok 1. (Step 1.) General Medical Training';

- solving the designed situational tasks and tests on biochemical aspects of chemical safety;

- carrying out laboratory studies modelling the effect of hazardous compounds;

- creating safety cards of toxic agents and endogenous toxins according to the subject matter of classes.

The topic 'Studying the biotransformation processes of xenobiotics and endogenous toxins. Microsomal oxidation, cytochrome P-450' is of a particular didactic significance, as it makes it possible to build a holistic picture of the hepatic detoxification function, mechanism of the negative effect of chemical compounds, their modification and clearance in the human body. For arranging the independent work of students, there are video-lectures prepared 'Biochemical trends in chemical safety. Part I: Recent Principles of Structure and Isolation of Chemical Substances" and "Biochemical Trends in Chemical Safety. Part II: Biotransformation of Xenobiotics and Endogenous Toxins" is broadcast on YouTube, the NMU TV channel.

As preparations to the practical class with this topic, future doctors were doing a project aimed at using the chemical safety knowledge for:

- developing the medical judgment about the understanding of the effect of chemical compounds on the human body;

- propaganda of a healthy lifestyle and preventive community healthcare;

- healthcare and maintenance.

Therefore, future doctors completed the competence-based training on occupational chemical safety with the use of designed instructions and methodical recommendations for the safe operation of medications, chemical reagents in the laboratory practice, qualification of risks and potential hazards according to the international standards ISO, implementation of the regulations of the International Occupational Health & Safety Assessment Series (OHSAS), prevention algorithms for occupational injuries in the chemical laboratory (Gaiova et al., 2017). The regulatory documents and requirements of the national, European and International legislations were employed: 'Material Safety Data Sheet. General Requirements' State Standard of Ukraine (DSTU) International Standard (GOST) 31340:2009; 'Safety Data Sheet for Chemical Products' ISO 11014:2009; EU Regulation No. 1272/2008; EU Regulations 1907/2007 REACH. The test was carried out, and the case-study method was used for assessing the knowledge of chemical safety standards to be adhered to in the settings of a clinical laboratory and safe use of medicines. The tests were carried out (Herush et al., 2016). The case study method was used for assessing the knowledge of implementing the chemical safety

standards in the professional activities in the settings of the clinical laboratory and safety of medications to apply. For students' individual work, the methods and techniques for assessing the conformity of a chemical reagent, medication with the material safety data sheet were elaborated.

Integrated meetings of the clubs at the departments of bioorganic and biological chemistry and hygiene and ecology, a scientific-methodical seminar in cooperation with the Hygiene and Ecology Institute of O. O. Bogomolets National Medical University were held at the final stage of the formation of future doctors' chemical safety competence.

After finishing the goal-oriented pedagogical impact, the levels of formedness of the motivation-value, cognitive and activity criteria of future doctors' chemical safety competence were studied in accordance with the indices devised.

A questionnaire was designed for assessing the formedness of the motivation-value criterion of future doctors' chemical safety competence in the course of studying bioorganic and biological chemistry (Ishchenko A., 2021). In this questionnaire, it was offered to students to assess their motivation and attitude to the problem given according to the scale 0 to 4, where 0 is the lowest value and 4 is the highest value of motivation.

According to the overall sum of points, four levels of formedness of the motivation-value criterion of future doctors' chemical safety competence in the course of studying bioorganic and biological chemistry were identified: low (0-10 points); average (11-20 points); adequate (21-30 points); high (31-40 points).

The formedness of the cognitive criterion of future doctors' chemical safety competence was assessed in accordance with the indices devised by testing (Shmyhol I. V., 2013). The answers were formed in view of Bloom's taxonomy and by following such a phasing of their formation: a purpose of tests was set; learning materials were selected, and a test matrix was designed; a databank of test tasks was formed according to the cognition levels; an expert evaluation of test materials with their further condemnation and selection of the best test tasks was performed; a test was formed, and the testing was carried out; test results were analysed by means of mathematical statistics (Classical Test Theory), and an inference was drawn. For a diagnostic purpose, a final test was devised, which consisted of 50 test tasks. The levels of formedness of the cognitive criterion were allotted correspondingly: low – to 70% (0 to 35 test questions were completed); average – 71-80% (36-40 test questions were completed); adequate – 81-90% (41-45 test questions were completed); high – 91-100% (46-50 test questions were completed).

The formedness of the activity criteria of future doctors' chemical safety competence in the course of studying bioorganic and biological chemistry was assessed by the method of observation of students' performance in solving situational tasks, cases, preparing and presenting projects.

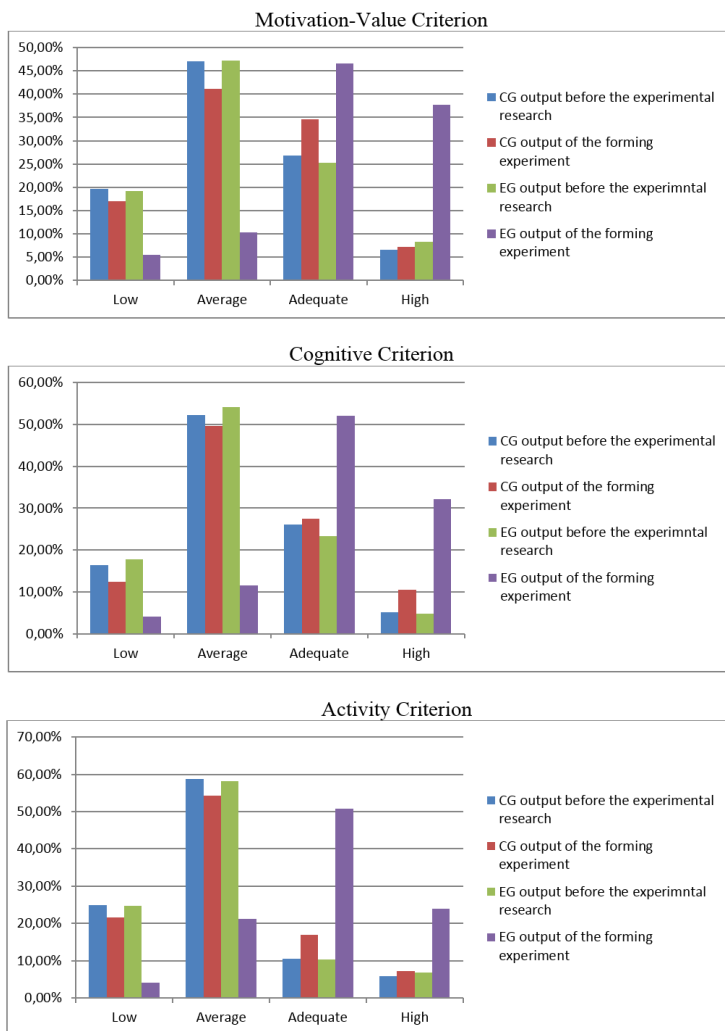


Fig. 2. Formedness levels of the chemical safety competence in the CG and EG in the course of studying bioorganic and biological chemistry before and after the experimental research (devised by the authors)

Respectively, four levels of formedness of the activity criteria of future doctors' chemical safety competence in the course of studying bioorganic and biological chemistry were identified: low (0-10 points); average (11-20 points); adequate (21-30 points); high (31-40 points).

The efficiency of the designed methods and techniques for forming the chemical safety competence of medical students on grounds of the tests performed outlines the degree of its successive functioning in achieving the goal set.

Conclusions

The scope, structure, criteria of the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry and respective indices and levels of their formedness have theoretically been substantiated.

The structure of the chemical safety competence has three components identified: motivation-value (formedness of steady intrinsic motives and understanding of the practical value of interpreting and applying the chemical safety biochemical aspects in the medical and preventive activities of future doctors); cognitive (realising the substantive patterns – a contemporary view of chemical safety and biological aspects of chemical safety); activity (using the chemical safety knowledge, skills and capacities). The indices and requirements to the levels (low, average, adequate, high) of formedness of the motivation-value, cognitive and activity criteria of the chemical safety competence have been described.

The paper has provided an outline of the methods and techniques for forming the chemical safety competence of future doctors in the course of studying bioorganic and biological chemistry, which prescribe the application of modern teaching methods (project design, solving situational tasks, carrying out laboratory tests that model the effect of hazardous chemicals, testing), studying means (glossary of chemical safety biochemical aspects; video-lectures and methodical recommendations for students' independent work), individual and group activities of students.

The author has provided the results of the assessment of the methods and techniques for forming future doctors' chemical safety competence in the course of studying bioorganic and biological chemistry that confirm statistically significant positive changes in the formedness of chemical safety competence of the experimental group students as opposed to the students in the control group, which prove the efficiency of the proprietary methodology.

The accuracy of the results obtained has been confirmed by Pearson's chi-squared test.

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