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**DEVELOPMENT AND STRUCTURE OF THE DISCIPLINE
“APPLIED CHEMISTRY IN MEDICINE” (ELECTIVE COURSE)
AT THE SCHOOL OF MEDICINE**

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Abstract

Along with teaching the natural science and medical principles, it is the author's proposal to create a new subject for electives, “How Applied Chemistry Helps in Medication” to see education level of medical application in higher education students within the Faculty of Medicine. This elective tries to amalgamate two different topics involving both chemistry and medicine. Besides this, it places serious emphasis on the importance of public health within the context of medical practice, of the significant role chemical principles may play in the modern health care system. Students have an opportunity to investigate subjects like environmental toxicology, pharmaceutical chemistry, and chemical risk assessment in which they can perceive the chemistry’s face with the public health field. The knowledge about disease prevention strategies, health promotion and community wellness obtained as a result can enhance the skillset students need to work towards evidence-based approaches in disease prevention. The course is designed as a 3.0 credits ECTS specified by the regulatory requirements.

Thematic subjects get covered and include chemical principles, toxicology, pharmaceutical chemistry, environmental toxicology, and chemical risk assessment. Sessions are designed to provide a complete picture of the domain and the methodological toolkit, while at the same time they are interactive and practical by applying theoretical concepts to real-life situations. Introduce the development of problem-solving and critical thinking as one of the learning objectives.

Key words: applied chemistry in medicine; teaching; elective discipline; work program.

The actual process of the higher medical education being developed in Ukraine is complex, being directly connected to the country's desire of the educational area and being integrated into the European and global educational community [6]. We see, clearly, the growth in the power of the interdisciplinary links and progress of the educational scene, thus, a great leap in the performance of the educational systems is achieved [7]. As medical education continues to promote our future doctors who can be of maximum impact at personal and social levels, electives courses for students are of various roles in psycho-pedagogical functions which are fundamental. On one side, they requisite the widening of natural science courses, which in turn will promote deeper exploration of chemical specialties such as “Medical Chemistry” and “Bioorganic Chemistry”. Alternatively, contribute to closing the gaps of the foundational educational programs [1, 4, 6, 8]. These courses are usually very important in creating a faith in the one who may be able to play the specific tasks inside the health care and the ability to solve issues which will be required in the medical future [1].

Moreover, consider that the applied chemistry role is to support public health, it is obliged to underline the way how the today's chemistry can handle the existing contemporary health problems. Conveying the public health values and concepts into the curriculum of the “Applied Chemistry in Medicine” course, will enable students to obtain the required knowledge and develop the necessary skills to deal with the key challenges associated with the chemical exposures, environmental toxins, and the issues related to the safety of the pharmaceuticals [3, 5]. Therefore, the development of the thematic sessions and recommendations for the work program is done hand by hand with this article which further looks at the intricacies of teaching applied chemistry in a way that envisions broader comprehension of its influence on public health field among first-year medical students at faculty of Medicine.

The aim of the work is to develop the structure of thematic sessions, recommendations for creating a work program, and analysis of the peculiarities of teaching the discipline “Applied Chemistry in Medicine” (an elective course) for first-year students of the medical faculty specializing in “Medicine”, field of knowledge 222 “Healthcare”.

Material and Methods

Curriculum Development: Collaborate with an array of experts in chemistry, pharmacy, toxicology, and medical education to tailor the program to include all key topics and learning objectives that are specific to the overlap of chemistry and medicine; Consider the feedback from those stakeholders, for example, faculty members, medical students and practicing healthcare workers, through focus groups, surveys, or interviews, so that there is agreement between the students' educational goals and the education goals.

Content Creation: Design and draw up a comprehensive agenda that addresses the ongoing toxic issue, the mechanism of action of commonly found toxic agents, pharmaceutical chemistry, environmental toxicology, and chemical risk assessment as well as public health; Collect necessary educational materials including textbooks, scientific articles and multimedia from various resources, for the students understanding process and also to understand the key concepts; Build instructional aids like lecture presentations and work practices to heighten understanding of chemical concepts and their application in the medical field.

Implementation: To determine the student's grasp of the topic, input the assessments with quizzes and presentations that are in line with the objectives and the content of the course.

Results

Theoretical Part

According to the Law of Ukraine “On Higher Education” (point 15 of part one of article 62), Ukrainian higher education students are guaranteed the right to choose educational disciplines within the framework provided by the relevant educational program, accounting for no less than 25% of the total ECTS credits [2]. Analysis of the literary data concerning the preparation for any elective course related to the medical-chemical direction, including the course “Applied Chemistry in Medicine”, allows us to formulate a series of general recommendations for preparing instructors for such courses:

1. Systematization and separation of the "core" of information on chemical and biological aspects. The main task at this stage is to determine what and to what extent should be subject to this transformation.

2. Goal setting. This stage involves didactic analysis of goals and creating a target project. There should be a clear connection between learning outcomes and the model of the future specialist.

3. Transformation of the content of professional activity into didactic objects through analysis, generalization, selection, didactic reduction, and qualitative material reduction. Relationships between methods and forms of scientific cognition and means of educational communication are also built.

4. Designing the technology of studying the elective course.

5. Instrumentalization, formatting of selected content, and technology of its mastering in the form of programs, educational and methodological manuals, and other didactic materials intended for instructors and higher education students.

Practical Part

Methods and forms of learning play an important role in the educational process, determining the specialization requirements, the possibility of personal and self-development, and considering the level of preparation of higher education students. Therefore, the main priorities of teaching methods for elective courses are focused on interdisciplinary integration, contributing to the formation of a holistic worldview; learning through experience and cooperation; interactivity; consideration of individual characteristics and needs of higher education students.

The features of elective courses include voluntary choice by higher education students, but mandatory attendance within a specific profile, variability of programs in content (subject-oriented and interdisciplinary), short duration (1.5-3.0 credits), completeness, originality of content, recording and evaluation of educational activities and achievements of higher education students at the discretion of the higher education institution.

The elective course "Applied Chemistry in Medicine" is designed for first-year higher education students who have completed the basic course of the discipline "Medical Chemistry".

This course is aimed at enhancing the theoretical preparation of higher education students, understanding the content of chemical phenomena occurring in living organisms, using chemical laws in diagnostics and treatment of diseases, understanding the physio-chemical principles of action of medicinal preparations used in modern medicine; studying the physio-chemical aspects of the most important biochemical processes and homeostasis in the body; mastering the skills of studying scientific, medical, and chemical literature; forming and developing practical skills in higher education students (solving problem and situational

tasks, designing and conducting experimental work); demonstrating the importance of chemistry in life, the specificity of using chemical agents in household processes, the impact of synthetic chemical substances on the environment; ability to conduct research in various fields of modern applied chemistry.

According to the work program of the educational discipline "Applied Chemistry in Medicine," it consists of 3.0 credits. According to the set goals and tasks, the structure of the course includes 9 blocks (Table 1).

Table 1

Structure of the Elective Discipline "Applied Chemistry in Medicine"

Block	Topic
1	Toxicologically Important Substances
2	Water in Living Systems. Solutions. Solubility of Drug Molecules
3	Medical Solutions and Gases
4	Surfactants and Their Importance in Human Life. Chemistry of Surfactants and Detergents
5	High Molecular Compounds and Polymers for Medical-Biological Applications
6	Food Products and Beverages and Their Quality
7	Sorption of Biologically Active Substances
8	Nanotechnologies in Medicine
9	Chemical Weapons. Means of Protection

Thus, the topics of practical classes and self-study cover the most important issues that students must master when studying the discipline.

In the first block. Among other things, the multidimensional exploration of ubiquitous hazardous compounds implies prominent consequences for public health. Toxicology studies of the individual effects of chemical toxins, including inorganic compounds, heavy metals and organic chemicals. Through analytical chemistry disciplines, the toxins can be identified and quantified. More importantly, the biochemistry links up with the toxicology it shows the mode of metabolism of toxic things by the body as well as, the medical intervention and preventive measures are ensured. This achievement of environmental surveillance and public health measurement is made possible by the provision of these tools. This tutorial doesn't just certify graduates with the ability to respond to questions in the field of toxicology and public health, but most importantly, it enables them to progress to a step further and join key

initiatives for the prevention, control and containment of chemical hazards and promotion of community welfare.

This block emphasizes general concepts of toxicology and its historical development. Higher education seekers are encouraged to delve into the effects of inorganic substances on the human body (O_3 , SiO_2 , HCN, CO, nitrides, nitrates, sulfides, etc.), the most toxic metals (a full list of metals and their biochemical roles are covered in the course “Medical Chemistry”), organic compounds (benzene, toluene, polycyclic hydrocarbons, methanol, ethylene glycol, phenol, formaldehyde, etc.), and carcinogens.

Block 2 is dedicated to solutions and the primary solvent – water. Water is vital as a body temperature stabilizer, transporter of nutrients and digestion products, reactant and reaction medium in most chemical transformations, conformational stabilizer of biopolymers, and as a substance facilitating the dynamic behavior of macromolecules. It is found in various plant and animal products as a cellular and extracellular component, a dispersing medium, and a solvent, affecting their consistency, structure, appearance, taste, and shelf life. Water can fulfil its hygienic role only when it meets quality standards in terms of sensory, chemical, and bacteriological properties. Otherwise, poor-quality water can lead to various infectious diseases.

Liquid dosage forms (LDF) constitute over 60% of all pharmaceuticals prepared in pharmacies. This session illuminates the general concepts of what solutions are, their components, classification, the understanding, and significance of solutions in medical practice, and the ability to calculate the amount of substance for preparing solutions of different concentrations. LDFs are a prevalent pharmaceutical form today and hold significant prospects for the future in creating new medications.

Infusion solutions represent the most complex group of parenteral medications. They include physiological solutions, which, in their composition, can maintain cell and organ viability in large quantities without disturbing physiological equilibrium in the body. Infusion solutions are complex saline solutions that, with their osmotic pressure, ion composition, and pH level close to blood plasma pH, can support cell and organ vitality without causing significant changes in physiological equilibrium in the body. They must contain ions of vital substances in the same proportion as they are found in blood plasma (Na^+ , K^+ , Ca^{2+} , Mg^{2+} , PO_4^{3-} , etc.), i.e., be isotonic.

Annually, 50-70 new genuinely original pharmaceuticals are registered worldwide, with ongoing development of new ones. This is driven by the emergence of new diseases and new strains of microorganisms resistant to medications. Currently, in the search for structural

analogues of lead compounds, computer modelling based on QSAR (Quantitative Structure–Activity Relationship) is used. This method allows not only to screen out unpromising compounds but also to provide recommendations for targeted synthesis. QSAR can determine the relationship between the chemical structure of substances, their physicochemical properties, and the pharmacological activity of a specific drug substance or group of drug substances.

The third block, "Medical Solutions and Gases," explores to higher education seekers the chemical composition and chemical-biological action of solutions and gases on the human body, as well as their application in medicine.

As a reminder, medicine is a field of science and practical activity aimed at preserving and strengthening human health, as well as diagnosing and treating diseases. Disinfection involves a set of measures aimed at treating premises, surfaces, instruments, and other objects in the environment to rid them of various pathogenic microorganisms. Special attention is paid to disinfection in healthcare facilities, as healthcare workers are most at risk of infection with various viral infections due to their constant contact with human biological materials (blood, damaged tissues, etc.). The following issues should be addressed: disinfection; levels of disinfection; chemical characteristics of medical disinfectants; water purification in field conditions; sterilization; prevention of surgical infection. Additionally, students must formulate an understanding and definition of the concept of "sterilization" and acquire theoretical knowledge and practical skills in water and medical instrument sterilization.

Oxygen-respiratory and anesthesia equipment are widely used in cases of emergency assistance for oxygen deficiency and for anesthesia during trauma and surgical procedures.

In the last decade, effective treatment methods for therapeutic patients using the inhalation of inert gases have been developed. The use of xenon, krypton, and helium allows achieving a positive effect in the treatment of therapeutic patients without the use of potent sedative and muscle relaxant drugs, reducing the treatment time for hospitalized patients with inflammatory respiratory diseases.

Block 4. The aim of this block is to provide higher education seekers with an understanding of the basic properties and behavior of solutions of colloidal surface-active substances (SAS) - surfactants and detergents - in aqueous solutions. Familiarization with the most important areas of SAS use in medicine and pharmacy, including the modification of surface (interfacial) layers. Familiarization with specific types of complex SAS, primarily polymers and phospholipids, as well as with micelle formation processes in organic,

particularly non-polar solvents, where the formation of reverse micelles and microemulsions occurs.

Block 5. The modern era is often referred to as the age of atoms and polymers. The penetration of synthetic fibers, plastics, and elastomers into all spheres of human activity has led to the rapid development of modern chemistry of high-molecular compounds (HMCs). Equally relevant in our time are topics related to HMCs and polymers for medical and biological applications. The aim of this block is to understand the general characteristics of the structure and composition of HMCs, study the biological role and application of the most important HMC solutions, interpret the physicochemical properties of proteins, which are structural components of all body tissues, and form systematic knowledge among higher education seekers about the physicochemical properties of HMC solutions, their application in medicine, and draw conclusions regarding the charge of dissolved biopolymers based on their isoelectric point. HMC solutions are widely used as pharmaceuticals; auxiliary substances in the manufacture of various pharmaceutical forms (bases for suppositories and ointments, emulsifiers, and stabilizers in the production of suspensions and emulsions, as prolongates, thickeners, film formers); packaging material for dispensing drugs, in the manufacture of vials, films, caps, jars, etc.

In medicine and pharmacy, artificial and synthetic polymers are used. They are used to make tooth and gum prostheses, tissue substitutes, blood plasma, vessels, bones. They are also used in the "artificial kidney" apparatus, and so on. Polymers are used to manufacture modern pharmaceutical forms, prolonging the action of drugs in the body.

Block 6. Nutrition, along with other environmental conditions, ensures the optimal development of the human body, its physical and mental performance, sufficiently high resistance to negative factors affecting humans, maintains their immunobiological properties, increases resistance to infectious diseases, and the influence of toxic substances. The physiological characteristics of the human body should be considered in the context of its interaction with the environment. This interaction occurs through the exchange of substances and energy. A student should be able to understand and know: the concepts of "food additives," "dietary supplements," "xenobiotics"; classification of food additives; positive and negative consequences of using food and biologically active additives; ways of contaminating food and beverages with harmful substances; contamination with radionuclides; the influence of nutrition on human life; food additives as possible contaminants, allergens, etc.; social toxicants; regulation of contaminants in beverages; the impact of beverages on drug intake. Any food products are an excellent environment for the reproduction of microorganisms,

especially if the basic rule of their storage or preparation - temperature regime - is violated. Therefore, sorbents, which are used as first aid for intoxication of the body, are relevant and appropriate. Hence, the next block is formed.

Block 7. It is impossible not to consider such important issues as sorbents and enter sorbents, pharmacological properties of carbon enter sorbents. Principles of treatment of acute poisonings, basic antidotes. Rational treatment of infectious diseases consists of combining the influence on the leading link in the infectious process, i.e., the pathogen, and neutralizing the toxins it produces - detoxification. Detoxification is a component of pathogenetic and symptomatic therapy and involves the removal of toxic substances from the body using efferent physical, physio-chemical, and physiological methods. Sorption methods of detoxification are based on the selective removal of toxic substances when the liquid media of the body (blood, plasma, lymph, gastric juice, chyme) meet sorbents - synthetic or natural preparations of various structures that bind exogenous and endogenous toxic substances through adsorption, absorption, ion exchange, or complex formation. Knowledge of the chemical composition of sorbents and the mechanism of their action will help the future physician prescribe effective treatment.

Block 8. This block is very relevant, especially now, during the state of war, and sheds light on issues related to chemical weapons. Chemical weapons are highly toxic substances, as well as ammunition containing them, or devices used for their dissemination, specifically designed to cause, in small doses, harm to humans, resulting in death, temporary disability, or permanent damage to human, animal, plant, and technical health through chemical exposure. The most important element of ensuring chemical safety for the population is the implementation of medical measures to preserve life, health, and professional capacity in peacetime and wartime. It is proposed to consider the following issues: features of chemical weapons; ways of getting toxins into the body; biotransformation of xenobiotics in a living organism; poisonous and highly toxic substances of neuro-paralytic action; poisoning with organophosphorus compounds; characteristics of the center of chemical contamination and the zone of chemical contamination.

Block 9. Nanomaterials and nanotechnologies are becoming increasingly important in science, medicine, and industry as materials of the future. The size of nano systems allows them to move freely inside living organisms, which can be used in creating vectors for drug delivery; disease diagnostics; creating structural biomaterials. Soon, nanotechnologies will play a leading role in driving innovation in medicine. Nanomedicine is developing where genomic and proteomic data are combined with the possibilities of creating materials with

new properties at the nanometer level. There are 5 main areas of application of nanotechnologies in medicine: delivery of active pharmaceutical ingredients, new methods and means of treatment at the nanometer level, in vivo diagnostics, in vitro diagnostics, medical implants. Targeted drug delivery is a method of administering pharmaceuticals to achieve a therapeutic effect in humans. Directed drug transport to the focus of pathological process development allows achieving an increase in the effectiveness of already existing drug therapy. Such targeted delivery ensures a more effective action of drugs and preserves surrounding tissues. Therefore, it is necessary to focus on the following issues: classification of nanoobjects; methods of synthesizing nanoparticles, carbon nanomaterials and porous nanoobjects, liposomes, the role of nanotechnologies in disease diagnostics, the use of nanotechnologies in oncology, neurology, cardiology, and other areas of medicine, nano cosmetics.

To successfully master elective courses, a developed base of information resources of higher education institutions (library fund of scientific and popular periodicals, automated information retrieval systems, various Internet resources, etc.) is also necessary, to which students should have free access. Mastering the content of the course “Applied Chemistry in Medicine” will enable medical students to approach the study of other programs with a better understanding, not only of disciplines of a chemical nature but also of many medical and biological disciplines.

Conclusions:

1. The creation and development of new elective courses allow selecting the most effective innovations in the required field of knowledge, incorporating those into the curriculum that prove themselves and considering the interests and desires of higher education students who are interested in their own improvement.

2. Teaching the academic discipline “Applied Chemistry in Medicine” (an elective course) at the medical faculty is necessary for the comprehensive mastery of medical knowledge by higher education students using chemistry.

3. The main directions and thematic session scheme of the new elective course “Applied Chemistry in Medicine” are proposed. Recommendations for creating a syllabus for this discipline for first-year students of the medical faculty are provided.

4. The relevance of each block of the elective course “Applied Chemistry in Medicine” has been considered, analysed, and detailed explanations have been provided.

5. It is worth to mention that the approach with public health principles incorporated in the syllabus of "Applied Chemistry in Medicine" acts as a vital tool in the

sense of linking scientific knowledge with effective healthcare. Students can acquire a wider perspective by studying some of these issues, alongside the foundational chemistry concepts. Their understanding of the factors that contribute to improving population health outcomes becomes wider. Such interdisciplinary approach arms the future professionals with the instruments that can cope with individual needs of the patients as well as with the society public health issues, which lead to the more realistic and targeted medical care approaches. This innovative elective course enables learners to be role-players in creating health equity as they work to improve general health of people they serve.

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Authors contribution:

Conceptualization, (Grekova A.V. & Burdina Ia.F.); methodology, (Shyrykalova A.O.); methodology, (Burdina Ia.F. & Kolomiets P.V.); formal analysis, (Gridina I.R.); data curation, (Grekova A.V.); writing—original draft preparation, (Grekova A.V. & Abbassi Reda); writing—review and editing, (Burdina Ia.F., Gridina I.R., Shyrykalova A.O., Abbassi Reda & Kolomiets P.V.).

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