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USE OF DIGITAL TECHNOLOGIES IN TEACHING THE TOPIC "ENVIRONMENTAL RADIATION AND RADIATION BACKGROUND"

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Abstract. This article analyzes the scientific and pedagogical foundations of using digital technologies in teaching the topic "Environmental Radiation. Radiation Background" for students majoring in "Fundamental Medicine" who study the course "General and Medical Radiobiology." The role of multimedia tools, virtual laboratories, simulation platforms, and interactive assessment systems in the effective assimilation of concepts such as radiation background, sources of ionizing radiation, mechanisms of biological effects, and radiation safety is highlighted. In addition, the methodological aspects that educators should consider in effectively organizing lectures and practical classes are presented.

Keywords: radiobiology, radiation background, environmental radiation, digital education, virtual laboratory, fundamental medicine, ionizing radiation.

Introduction

At present, due to the integration of medicine, ecology, biology, and physics, the practical significance of radiobiology is steadily increasing. In particular, the development of X-ray diagnostics, computed tomography, radiotherapy, nuclear medicine, and environmental monitoring systems requires an in-depth study of radiation-related knowledge. From this perspective, the topic "Environmental Radiation. Radiation Background" occupies a special place in the course "General and Medical Radiobiology."The works of E.J. Hall and A.J. Giaccia [1], Sh. Khushmatov et al. [2], O.M. Khramchenkova [3], S.P. Yarmonenko [4], and A.N. Remizov [5] are considered fundamental sources that comprehensively explain the mechanisms of ionizing radiation effects on cells and tissues. UNSCEAR reports provide the most reliable statistical data on global radiation background and natural and artificial sources of radiation. The IAEA safety standards constitute one of the main regulatory documents for organizing radiation protection in medical and educational institutions [6,7]. Modern pedagogical research demonstrates that multimedia tools, virtual laboratories, and interactive educational technologies significantly increase the level of mastery in teaching natural sciences. Along with traditional lecture methods, the application of digital technologies in teaching this topic improves the quality of the educational process. Since radiation is an invisible physical phenomenon, the use of visual models, simulations, and real databases is highly effective in helping students conceptualize it.

Main Part

Environmental radiation refers to the totality of ionizing radiation present in the human living environment. These radiations originate from natural and artificial sources. Natural sources include cosmic rays, radionuclides in the Earth's crust, radon gas, and radioactive elements found in water and food products. Artificial sources include X-ray devices, computed tomography, radiotherapy equipment, industrial radiography, and nuclear energy facilities. Radiation background represents the general level of ionizing radiation in a particular area. It is usually measured in microsieverts per hour or millisieverts per year. Depending on geographical location, geological composition, altitude, and the level of technogenic activity, radiation background varies from region to region. Radioecology studies the types and sources of ionizing radiation of natural and anthropogenic origin, investigates the patterns of radionuclide distribution within biosphere components, and is divided into several branches. Theoretical radioecology studies issues related to radionuclide migration in ecosystems; experimental radioecology examines the mechanisms of ionizing radiation effects on biological organisms and scientifically substantiates measures for protection against radiation exposure.

Radioecology is directly subdivided into animal radioecology, plant radioecology, hydroradioecology, microorganism radioecology, forest radioecology, agricultural radioecology, and other areas. It is well known that one of the practically important tasks of ecological biophysics, including radiation ecology, is the scientific substantiation of monitoring environmental pollution levels caused by anthropogenic factors (chemical and physical, including radiation pollution) and developing measures for their elimination. For this purpose, the international "Biotest" program was developed in 1989 to assess environmental pollution levels.

In radiation ecology, biotesting and bioindication methods are used to evaluate the degree of environmental contamination with radioactive waste possessing various toxic properties. Biotesting (bioassay) is a method of assessing environmental pollution levels based on changes in the morphological, genetic, biochemical, and other structural-functional systems of biological test samples obtained from polluted environments under laboratory conditions. Bioindication is a method of assessing the current environmental state based on the response reactions of living organisms to harmful emissions of natural and anthropogenic origin within their habitat.

Digital technologies serve as important pedagogical tools in explaining radiation phenomena. Through these technologies, students gain the opportunity to observe, analyze, and model invisible physical processes. Multimedia presentations and animations demonstrate complex processes such as the interaction of alpha, beta, and gamma radiation with matter, ionization processes, and DNA molecule damage in a simple and understandable form. Through 3D anatomical models, the effects of radiation on the human body and the localization of radiosensitive organs and tissues can be explained. This is especially important for students specializing in fundamental medicine, as they will subsequently study clinical disciplines as well.

Open databases of international organizations such as the IAEA, UNSCEAR, WHO, and NASA Earth Data provide real information on global radiation background, the consequences of radiation accidents, and radon risk zones. Based on these data, students learn to draw ecological and medical conclusions. Virtual laboratories are of particular importance in practical training sessions. Using a virtual model of the Geiger–Müller counter, students study the principles of measuring radiation intensity. Situations such as the reduction of radiation levels with increasing distance from the source, the effectiveness of different shielding materials, and radioactive decay processes can be simulated.

With the help of Excel, SPSS, or Python software, it is possible to process statistical data related to radiation background, construct graphs, and analyze results. This contributes to the development of students' scientific research competencies. In addition, assigning tasks based on clinical cases is beneficial. For example, issues such as the risks of X-ray examinations, dose loads resulting from CT scans, or the development of preventive measures in areas with high radon concentrations contribute to the development of students' professional thinking.

When teaching this topic, educators should first connect theoretical knowledge with practical application. Radiation doses, biological effects, and protection principles should be explained not only as formulas but also through real medical examples. Secondly, it is important to develop a culture of radiation safety. Concepts related to the ALARA principle, the time–distance–shielding rule, personal protective equipment, and individual dosimetric monitoring should be instilled in students' minds. Thirdly, the use of interactive methods increases lesson effectiveness. Case studies, problem-based learning, flipped classrooms, debates, and group discussions encourage active student participation. Fourthly, it is advisable to use digital tools in the assessment process. Platforms such as Moodle, Google Forms, Kahoot, and Quizizz enable the organization of rapid tests and automatic analysis of results.

Conclusion

Teaching the topic "Environmental Radiation. Radiation Background" based on digital technologies significantly increases the effectiveness of the course "General and Medical Radiobiology." Multimedia presentations, virtual laboratories, real databases, and interactive testing systems strengthen students' theoretical knowledge, develop their practical skills, and form a culture of radiation safety. Therefore, teaching this topic to students of fundamental medicine through innovative pedagogical approaches is considered one of the urgent tasks of today.

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