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VISUALIZATION METHODS AS AN ELEMENT OF STEM EDUCATION

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Abstract: This paper examines visualisation methods and justifies their use in the teaching of chemistry-related subjects in the training of future doctors and pharmacists. Visualisation helps to improve students' retention of material, stimulate their cognitive activity, develop their skills and abilities, and enable them to apply the knowledge they have acquired in practice. The teacher's task is to select the appropriate method and use it effectively

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The information-rich nature of the modern world requires specialised preparation and a certain degree of adaptation of teaching materials in order to present them in a form that is most conducive to perception, understanding, assimilation and retention. Information visualisation technologies are becoming increasingly important today, as they ensure that the content of teaching materials is presented in a concise, clear and dynamic manner. The chemical disciplines (general, inorganic, physical, colloidal, analytical and organic chemistry) are fundamental disciplines within the medical and pharmaceutical education system. The study of these disciplines involves the development of integrated, general and specialised competences – basic knowledge to the extent necessary for mastering professional disciplines. Teaching is geared towards fostering chemical thinking, the ability to understand the chemical structure of

substances, the skill to analyse their properties, and the ability to interpret the results of such analysis. Chemistry subjects are among the most challenging general education subjects, involving a large volume of theoretical material; yet, at the same time, only a limited number of teaching hours are allocated to them. This significantly complicates students' ability to master the material, which, in turn, reduces their interest in learning. It is very difficult for students to successfully master the curriculum in chemistry. Therefore, the lecturer's task is to engage students in active learning and to increase their interest in studying chemistry, as the quality of the knowledge acquired depends directly on their interest in the subject.

It is very difficult for students to successfully master the syllabus in chemistry. Therefore, the lecturer's task is to engage students in active learning and to stimulate their interest in studying chemistry, as the quality of the knowledge acquired depends directly on their interest in the subject. Furthermore, in the realities of our daily lives, the high cost of materials for experiments and the scarcity of suitable laboratory equipment are pressing issues. In the teaching of chemistry, traditional teaching methods often fail to engage students sufficiently in the lesson. Unfortunately, this is a major drawback in the study of this subject, as one of the most effective methods of acquiring knowledge in chemistry is experimental laboratory work. We are convinced that practical laboratory sessions are an integral part of the learning process when studying chemistry. They provide practical experience that enables students to master the necessary skills when working with real equipment. Chemical laboratory experiments are one of the most effective methods of acquiring knowledge. Understanding the conceptual world of matter, phenomena and processes is characteristic of chemistry at the macroscopic level. To interpret and predict, we must use the language of the submicroscopic world. When studying chemical disciplines, it is important that students understand and are able to relate concepts across all three conceptual levels (macroscopic, submicroscopic and symbolic), which is a complex and challenging process for them. The gap between the three conceptual levels can, to a large extent, be bridged with the help of visualisation techniques [1, p. 40]. Thus, the ability to use modelling in the teaching and learning of chemistry is one of the key components of visual literacy in chemistry.

In this day and age, a time of dynamic development in science and technology,

the concept of ‘modern traditional forms of education and learning’ is no longer sufficient. Information and communication technologies (ICT) open up a new world of creativity and learning for students [2, p. 1200]. The use of ICT can be divided into two groups: the first group includes the computer used as a tool for information retrieval, communication and multimedia, whilst the second group comprises the computer as a scientific tool, such as a virtual laboratory, interactive modelling and computer-based laboratory work. [3, p. 301]. The specific features of using ICT in the study of chemistry offer certain advantages. Researchers suggest that an understanding of chemistry involves the ability to think at three levels: the macroscopic, the symbolic and the subatomic levels.

Students find it most difficult to understand the submicroscopic level – the particle level – as it lies beyond the scope of their experience. In such cases, interactive methods can be used as an effective tool. Multimedia demonstrations of experiments should not replace other teaching methods used in chemistry. A virtual laboratory can eliminate the uninteresting and tedious parts of experiments. The use of multimedia and virtual laboratories for studying chemistry facilitates teaching, as it allows for the integration of three levels: understanding chemistry, visualisation and modelling of chemical processes.

In chemistry generally, laboratory experiments are one of the most effective methods of acquiring knowledge. Experiments can be divided into classical and virtual ones.

The classical experiment is the best-known method of practical work and is most frequently used when studying chemistry. Pupils practise practical skills, develop the ability to describe chemical changes, learn about the physical and chemical properties of substances, and adhere to health and safety rules whilst working in a chemistry laboratory; this enables them to consolidate and expand their knowledge, abilities and skills, as well as to develop an experimental approach as a fundamental form of research work.

Laboratory work enables pupils to develop and deepen their scientific literacy, the fundamentals of scientific work, analytical thinking and the ability to link theory with practice.

Virtual experiments are carried out in a virtual environment. A virtual laboratory

has many advantages. We can carry out dangerous experiments without putting ourselves or others at risk. Another advantage of virtual experiments is the availability of simulations. These can be carried out as many times as required at no extra cost

For us, a virtual chemistry laboratory consists of a systematic collection of self-filmed video clips depicting all the demonstration experiments in chemistry that are recommended for use in chemistry curricula.

A virtual chemistry experiment is regarded as a type of educational chemistry experiment; its main difference from a traditional experiment lies in the fact that computer technology is used to demonstrate or simulate chemical processes and phenomena, and during its execution, the student works with images of substances and equipment components that replicate the appearance and functions of real objects. Conducting a virtual experiment (demonstration, experiment or laboratory work) in a virtual laboratory involves simulating the actions that the user would carry out in a real laboratory [4, p. 342]

Of course, virtual chemistry experiments have certain drawbacks. The main drawback of a virtual experiment is its detachment from nature and from reality. Therefore, simulations are generally a good complement to, rather than a replacement for, the traditional chemistry experiment.

One method of visualisation is modelling. For example, when studying organic chemistry, students create ball-and-stick models, which enable them to establish a link between the structure and properties of different classes of organic compounds. During laboratory sessions, we simulate the washing and drying of glassware, as well as processes involved in the purification of reagents, weighing, microscopy, titration and so on. Chemical experiments are an effective method for visualising chemical reactions. They enable students to observe the signs of a chemical reaction (colour change, the formation or dissolution of a precipitate, the release of gas, etc.) and to explain the relationship between structure and chemical properties, to understand the essence of a chemical reaction, and to develop the ability to distinguish the essential from the secondary; draw conclusions based on observations and facts, and test these conclusions whilst solving research tasks. We encourage pupils to present the results of their research tasks in the form of a multimedia presentation, illustrating it with diagrams, schematics, graphs, etc. In cases where, for various reasons, it is not possible

to carry out a real experiment during the lesson, we use video demonstrations of experiments.

It is possible to demonstrate the entire experiment or a section of it. It is possible to comment on the demonstration, replay the recording, pause a particular frame, and so on. A video demonstration does not provide ready-made knowledge. However, it helps guide students towards independently identifying interrelationships and formulating conclusions. When studying certain topics, it is advisable to use algorithms, which enable students to structure the learning material and commit it to memory. When studying analytical chemistry, we suggest that students characterise cations using the following algorithm: membership of an analytical group; colour in solution; solubility of salts in water; formula and properties of the base characteristic of the ion; the salts' susceptibility to hydrolysis; the presence of redox properties; ability to form complexes; the action of a group reagent (chemical behaviour, analytical effect); identification reactions for the ion; and the use of compounds in pharmacy. Such a characterisation promotes the conscious acquisition of chemical knowledge and the development of logical thinking. Consequently, the use of visualisation in the teaching of chemical disciplines helps to improve students' understanding of the material, stimulate their mental activity, develop skills and abilities, and enhance their capacity to apply the knowledge they have acquired in practice. The teacher's task is to select the appropriate method and use it effectively.

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