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Developing Scientific Thinking in Pupils in Chemistry Lessons

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Abstract: This scientific article analyzes the development of students' scientific thinking through the application of modern pedagogical approaches in chemistry lessons. In the process of teaching chemistry, it is important not to limit instruction to the transmission of theoretical knowledge, but also to develop students' ability to think independently, find appropriate solutions to problem-based situations, and apply their knowledge in practical activities. In particular, the experimental nature of chemistry provides broad opportunities for developing students' creative and research skills. The article examines the development of creative thinking, the formation of scientific thinking, and the improvement of students' practical skills in chemistry education. The results of the analysis indicate that it is more effective to organize the learning process in a way that positions students not as passive recipients of ready-made knowledge, but as active participants who acquire knowledge through independent inquiry and experimentation.

Keywords: chemistry, STEAM education, method, knowledge, creativity, mathematics, approach, efficiency, theory, integration, practice.

Introduction. Chemistry is one of the fundamental sciences that is intrinsically linked to almost all aspects of human activity, including the production of foodstuffs, pharmaceuticals, agriculture, energy, transport, and construction materials, the development of many fields such as textiles, ecology and the creation of new materials is directly linked to the use of chemical knowledge and technologies. Therefore, the aim of chemistry education should not be limited to teaching only chemical concepts, laws and formulas. The educational process must also develop pupils' competencies in scientific thinking, problem-solving, conducting experiments, analysing evidence and devising new solutions.

In the education system, creativity is regarded as one of the key competencies of a pupil. It is incorrect to understand creativity solely as a capacity inherent in art or artistic activity. Scientific creativity also involves viewing a problem in a new light, putting forward various hypotheses, developing alternative solutions, interpreting experimental results from an unconventional perspective, and applying existing knowledge in new situations. The experimental nature of chemistry provides a wide range of opportunities for developing creativity. Observing chemical phenomena, comparing the

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properties of substances, planning reactions, interpreting experimental results and predicting how processes will change under different conditions all demand active cognitive engagement from the student.

Analysis of relevant literature (literature review). This research was conducted as a theoretical study based on a thematic analysis of the literature. In selecting sources, their direct relevance to the topic, scientific rigour and suitability for use in the context of chemistry or natural sciences education were taken into account.

These studies have provided an important methodological basis for organising the student's active cognitive activity in chemistry education. Particular attention has been paid by scientists from the CIS countries to the issues of methodological improvement of chemistry education. O.S. Gabrielyan, N.E. Kuznetsova, In the works of I.M. Titova and other researchers, the didactic potential of using scientific methods, observation, experiment, analysis, synthesis, modelling, hypothesis formulation and drawing theoretical conclusions in the process of acquiring and consolidating chemical knowledge has been substantiated.

These approaches are aimed at fostering in students not only subject-specific knowledge but also the methodological thinking that underpins the acquisition and consolidation of chemical knowledge.

In foreign research, this issue is addressed in S. Erduran's studies, which examine the role of scientific argumentation in chemistry education and the development of skills for defending scientific claims through evidence and logical justification. Research by A. Moon, M. Towns and colleagues shows that students face certain difficulties in understanding problems when solving chemical problems, and demonstrates the necessity of developing such skills through specialised pedagogical activities.

At the same time, an analysis of existing research shows that, Although certain components of scientific thinking scientific investigation, argumentation, critical thinking, problem-solving or experimental activity have been studied separately, the issue of integrating them within a common methodological framework has not been sufficiently developed.

Research Methodology. The concept of scientific thinking is not confined, in its narrow sense, to the mere acquisition of knowledge. It encompasses a series of interrelated cognitive activities such as identifying a problem, formulating a scientific question, proposing a conjecture or hypothesis, collecting and analysing evidence, drawing conclusions based on that evidence, and scientifically substantiating one's ideas. Scientific reasoning skills are recognised as one of the key components of effective science education in the 21st century.

Another important component of scientific thinking is scientific argumentation. Scientific argumentation does not mean that a student simply states a conclusion, but that they can defend that conclusion with evidence, scientific concepts and logical reasoning. In chemistry education, this skill is particularly important for explaining chemical reactions, interpreting experimental results, elucidating the properties of substances, and in decision-making processes concerning environmental

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or socio-chemical issues. The subject of chemistry, with its experimental basis, provides extensive opportunities for developing pupils' creative abilities. Through this subject, students have the opportunity to observe natural processes, analyse them, draw conclusions from experiments and develop scientific thinking.

Analysis and results. In teaching chemistry, fostering students' scientific curiosity is one of the key factors in enhancing educational effectiveness. Scientific thinking is the student's ability to understand, analyse and draw conclusions about phenomena and processes in a logical, well-founded and evidence-based manner. It includes the following aspects:

1.Identifying cause-and-effect relationships

2.Analysing observation and experimental results

3.Formulating a hypothesis

4.Drawing a scientific conclusion

What is a practical skill?

Practical skill is a student's ability to apply theoretical knowledge in practice. For example:

1.Performing laboratory experiments

2.Proper use of equipment

3. Preparing solutions, separating substances

4. Adhering to safety regulations

Conclusion and recommendations. To develop these skills during the lesson process, it is first necessary to shift from the traditional reproductive model of teaching to an approach based on the learner's active cognitive activity. In this case, the principle "teacher explains – student memorises" is replaced by the model "student explores – teacher guides." In this process, problem-based learning technology manifests itself as an effective didactic tool, Rather than presenting the learner with ready-made knowledge or answers, it is based on creating problem situations and questions that encourage independent thinking, hypothesis formulation, the search for evidence and the drawing of well-founded conclusions. Argument-based instruction is one of the effective pedagogical tools for developing students' scientific thinking, in which a student puts forward a scientific claim about a problematic situation, and substantiates it based on the results of experiments, observations, or other evidence, analyses alternative viewpoints and draws a logical conclusion.

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