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## CHEMICAL EXPERIMENT - A METHOD OF VISUALIZATION AND ASSIMILATION OF THE LAWS OF CHEMISTRY

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**Abstract.** *The concept of the New Ukrainian School requires teachers not only deep knowledge of their subject, but also a high level of methodological and practical training. One of the key components of the competency-based approach to studying natural sciences, in particular chemistry, is a chemical experiment. It acts not just as an illustration of theoretical provisions, but as a powerful means of forming research skills, critical thinking, cognitive interest and practical skills of students. Effective use of a chemical experiment in chemistry lessons is possible only if the teacher himself has a high level of training and professional skills. After all, a teacher in a lesson must not only technically competently organize and perform a chemical experiment, he must include it in the educational process, explain it to students and interpret the experimental results obtained in accordance with the purpose of its conduct.*

*In many secondary education institutions, there is a tendency to reduce the chemical experiment or to conduct it formally. This may be due to various reasons: lack of modern equipment and reagents, lack of time, overloaded programs, but most often - with insufficient methodological and practical training of the teacher to organize and conduct experiments. Secondly, the requirements for the teacher are constantly increasing: he must not only technically correctly perform the experiment, but also integrate it into the educational process, correctly interpret the results, ensure compliance with safety rules and form in students the ability to work independently with equipment and chemicals. Thirdly, the formation of stable practical skills and abilities in a future chemistry teacher is laid during studies in higher education institutions, but their improvement and adaptation to the real conditions of the school occurs throughout the entire professional activity. It is through systematic exercises, training and constant self-improvement that skills are transformed into mastery. The formation of the professional skills of a chemistry teacher makes it possible to create an idea of his professional activity during the conduct of all types of school chemical experiments as the main method of teaching this subject.*

**Key words:** *chemical experiment, professional activity, didactic tool, practical skills, analysis of results.*



### **Presentation of the main material.**

Chemistry as a natural science is inextricably linked with the experiment. It is not just an illustrative tool, but a way of verifying hypotheses and a source of new knowledge. In school education, a chemical experiment plays a multifaceted role, going beyond the simple demonstration of phenomena. A chemical experiment in school practice is a didactic tool that provides direct or indirect perception of chemical phenomena, their properties and relationships. It is a powerful tool for forming a scientific worldview, developing logical thinking and forming practical skills.

The study of the classification, content, methods of organization and methodology of including a chemical experiment in a lesson was carried out by prominent Ukrainian teachers N.M. Burynska, L.P. Velichko, A.K. Grabovyi, N.N. Chaychenko, O. G. Yaroshenko and others. Methodologists note that it is through the experiment that the student "gets involved" in the activity, gaining his own experience of discovering knowledge. Direct contact with substances, observation of their transformations, recording and analysis of the results make the process of teaching chemistry not only effective, but also exciting. The experiment contributes to the formation of such key competencies as the ability to learn throughout life, initiative and entrepreneurship, as well as natural science competence [1].

In addition, the importance of a chemical experiment lies in its ability to:

- form specific ideas about substances and processes, which is the basis for further theoretical generalization.
- develop observation, the ability to analyze, compare, generalize and draw conclusions.
- stimulate cognitive interest and motivation to study chemistry, transforming abstract concepts into real, tangible processes.
- cultivate accuracy, precision, responsibility and compliance with safety rules when working with chemicals.
- form practical skills in working with laboratory equipment and chemical reagents, which is an important component of pre-professional training.

To ensure maximum efficiency, a chemical experiment at school must meet a



number of requirements:

- ✓ safety: strict adherence to safety rules is an absolute priority. All experiments must be safe for students and the teacher.
- ✓ accessibility: the experiment must be understandable in content, and the equipment and reagents must be accessible for execution.
- ✓ scientificity: all processes must comply with scientific laws and theories, preventing falsification of results.
- ✓ clarity: visualization of processes is key to understanding.
- ✓ economy: rational use of reagents and time.
- ✓ problem-solving: the experiment must pose a certain problem to students, encouraging them to find a solution.
- ✓ age-appropriateness: the complexity of the experiment must correspond to the age characteristics and level of training of students [2].

Understanding these theoretical principles is the foundation for developing teacher skills, because without understanding the role and potential of experimentation, it is impossible to effectively apply it in the educational process.

Effectively conducting a chemistry experiment at school requires the teacher not only to have knowledge of the subject, but also a wide range of specific skills that go beyond pure academic training. These skills are integrated and interdependent, forming the professional competence of the teacher in this area. They can be conditionally classified into several groups.

### **1. Organizational skills.**

These skills are the basis for the successful start of any experiment and ensure its smooth execution.

Planning and preparation of the experiment: the teacher must clearly understand the purpose of each experiment, its place in the structure of the lesson. This includes selecting the optimal experiment in accordance with the didactic tasks, the age of the students and the available equipment. Planning includes anticipating possible difficulties, both organizational (for example, shortage of reagents, malfunction of the equipment) and methodological (students' misunderstanding of the instructions) [3].



Preparation of equipment and reagents: this skill includes not only knowledge of the nomenclature of chemical dishes and devices, but also the ability to check them for suitability, cleanliness, and tightness. The teacher must be able to correctly measure and weigh the required amounts of substances, prepare solutions of a given concentration, and check the expiration date of the reagents.

Organization of the student's workplace and demonstration table: the ability to rationally place equipment, ensure order and cleanliness, accessibility of necessary materials and at the same time limit access to hazardous substances. For a demonstration experiment, it is important to ensure visibility from all corners of the classroom.

Adherence to regulations and time frames: the teacher must be able to distribute the lesson time in such a way that the experiment is not only performed, but also sufficiently discussed, and the students have time to record the results and draw conclusions.

## **2. Methodical skills.**

These skills determine the effectiveness of the experiment as a teaching tool, transforming it from a simple manipulation into a meaningful learning activity.

Setting the experimental tasks: the teacher must clearly formulate the purpose of the experiment for students, interest them, create a problem situation that will encourage them to find a solution through the experiment. This may be a hypothesis that needs to be tested or a problem that needs to be solved.

Conducting high-quality instruction: the ability to clearly, concisely and clearly explain the sequence of actions using various means (verbal instructions, instruction cards, videos). Special attention is paid to safety instructions before starting practical work [4].

Support and assistance to students during performance: the teacher must be able to observe the work of students, provide individual assistance, correct mistakes, but not do the work for them. The ability to create an atmosphere of support and encouragement is important.

Analysis and interpretation of the obtained experimental results is one of the most



important skills. The teacher should help students connect observed phenomena with theoretical knowledge, explain the reasons for changes, formulate conclusions. The ability to ask leading questions, organize a discussion and summarize is key.

Formulating conclusions and integrating them into the learning process: the ability to summarize the results of the experiment, show their place in the studied topic, and also demonstrate the connection with real life or further topics.

Working on typical errors: the ability to identify common errors made by students during the experiment (both technical and conceptual) and effectively correct them, using errors as an opportunity for learning.

### **3. Technical skills.**

These skills relate directly to the technique of performing chemical operations.

Skills in working with chemical utensils and devices: the ability to correctly assemble devices for experiments, heat substances in test tubes and flasks, use measuring vessels, filter, settle, distill, etc.

Techniques for working with reagents: knowledge of the rules for handling different classes of substances (acids, alkalis, oxidants, combustible substances), the ability to correctly dose, dissolve, mix them.

Impeccable performance of demonstration experiments: the teacher must practice demonstration experiments to automatism so that they are bright, convincing and safe, and students can focus on the essence of the phenomenon, and not on the teacher's uncertainty [5].

### **4. Safety skills.**

Safety is a fundamental aspect of conducting any chemical experiment. The teacher is fully responsible for the life and health of students, so mastering safety skills is absolutely mandatory.

Deep knowledge of safety rules (TB) and labor protection: the teacher must be thoroughly familiar with the TB instructions for the chemistry room, the rules for handling different classes of chemicals (acids, alkalis, flammable, poisonous, explosive), as well as the principles of fire safety [4].

The ability to anticipate and prevent dangerous situations: this involves the ability



to identify potential risks during the experiment in advance, for example, the possibility of releasing harmful gases, explosions, splashing of corrosive substances. The teacher must take all necessary measures to minimize these risks (ventilation, use of protective screens, sufficient distance between students).

Skills in providing first aid for injuries and poisonings: the teacher must be able to act promptly and competently in the event of an accident: provide first aid for burns (thermal, chemical), cuts, poisoning, know the location of the first-aid kit and be able to use it. This also includes the ability to assess the severity of the situation and call for medical help if necessary.

Ability to ensure proper waste disposal: after conducting an experiment, reaction products remain, which are often dangerous or require special disposal. The teacher must know and follow the rules for collecting and disposing of chemical waste in accordance with environmental standards.

### **5. Diagnostic skills.**

Comprehensive possession of the above skills turns the teacher into a master of chemical experiments, who is able not only to technically perform the experiment, but also to integrate it into the educational process, turning it into a powerful tool for the development of the student's personality. However, these skills are not formed spontaneously, but require purposeful and systematic work.

The formation and improvement of a teacher's skills in conducting a chemical experiment is a continuous process that covers various stages of professional training and further pedagogical activity. This process requires a systematic approach that combines theoretical training with intensive practical training. The foundation of the professional training of a future chemistry teacher is laid precisely in higher education institutions.

The curricula of specialized chemical educational components should include a sufficient number of hours for studying general, inorganic, organic, analytical chemistry, as well as chemistry teaching methods. It is important that these courses are not limited only to theory, but have a significant practical component. Laboratory classes should be aimed not only at consolidating theoretical material, but also at



developing pedagogically oriented experimental skills [6]. This means that *students* should not just perform experiments on chemical reactions, but also learn to explain them, predict results, record observations, work with instructions, which they can then adapt for students.

Pedagogical practice is one of the most important stages in the formation of practical skills. During pedagogical practice, *students* have the opportunity not only to observe the work of experienced teachers, but also to independently plan and conduct lessons with a chemical experiment. It is important that the practice involves various types of experiments - from demonstration to individual laboratory work, with a mandatory detailed analysis of the experiments performed and receiving feedback from the methodologist and teacher-mentor. The emphasis should be on the skills of organizing students' work, ensuring safety, and interpreting results.

The introduction of special courses dedicated to the specifics of school chemical experiments into the curricula can significantly improve student training. Such courses may include: "Chemical Experiment at School", "Life Safety in the Chemistry Room", "Technique of Laboratory Work in Chemistry", "Techno-Chemical Experiment", etc. These courses may be aimed at deepening knowledge of modern experimental techniques, the use of new equipment, and the development of one's own experimental tasks.

We understand that a teacher's professional development does not end with receiving a diploma. The system of postgraduate pedagogical education and advanced training plays a key role in supporting and improving a teacher's professional skills. Regular courses that update teachers' knowledge of modern requirements for chemical experiments, new equipment, and innovative methods should have a significant practical component where teachers could practice new skills. Chemistry teachers can also improve their own methodological skills by taking short-term intensive programs aimed at practicing specific skills (for example, "Safe work with gases", "Making simple devices for a chemical experiment"); at master classes conducted by experienced teachers or scientists, where complex or non-standard experiments are demonstrated and analyzed, and the secrets of mastery in conducting experiments and



working with students are revealed; during webinars or online courses that provide access to up-to-date information and practical recommendations for teachers from remote regions, offering a flexible study schedule and the ability to review materials at a convenient time.

A significant part of a teacher's professional growth occurs due to his own initiative and active participation in the professional community, namely: independent study of scientific and methodological literature (regular familiarization with new research in the field of chemistry teaching methods, new manuals for chemical experiments, scientific journals; participation in professional communities; attendance at conferences, symposia, pedagogical readings; creation of his own arsenal of experiments (development of new ones, adaptation of existing experiments, search for safe and affordable alternatives to reagents). Modern educational technologies also open up new opportunities for the formation and improvement of chemistry teacher's skills in conducting experiments, overcoming some limitations of traditional teaching. Virtual laboratories and simulators are powerful tools that allow students and teachers to "perform" experiments in a safe virtual environment without using real reagents and equipment [7]. They are ideal for practicing the sequence of actions, studying the principles of operation of devices, and visualizing dangerous or expensive experiments. Interactive whiteboards and multimedia presentations: allow you to integrate videos of experiments, animations of chemical processes, 3D models of molecules, which makes the explanation more clear and dynamic. The teacher can use these tools to prepare students for the experiment, visualize its progress and analyze the results. Video instructions and video lessons allow teachers to learn new methods of performing experiments, review experiments that are difficult to reproduce in a school laboratory, and also use them to demonstrate to students who have missed classes or need additional explanation. Various educational portals, online resources and educational platforms such as MOOC platforms (Coursera, Prometheus), YouTube channels on scientific topics, specialized sites for chemistry teachers offer access to a huge number of methodological materials, video recordings of experiments, articles and forums for sharing experience. This contributes to continuous professional development. The



integration of these technologies into the process of training and professional activity of a chemistry teacher significantly expands the opportunities for forming and consolidating skills in conducting a chemical experiment, making this process more flexible, accessible and efficient.

### **Conclusions.**

The formation of a teacher's skills in conducting a chemical experiment at school is one of the key conditions for ensuring the quality of natural science education and the formation of key competencies of students. A chemical experiment is a fundamental didactic tool in teaching chemistry, which provides not only clarity, but also active cognition, the development of research skills, critical thinking and the formation of practical skills. Its effective use is possible only if the teacher has a high level of professional skills. Higher education institutions play a key role in laying the foundation for a chemistry teacher's skills in conducting a chemical experiment through specialized disciplines, intensive laboratory practice, pedagogical practice and special courses. An indispensable tool for updating and deepening knowledge and skills throughout the teacher's professional activity is his self-education, a system of advanced training, trainings, seminars, master classes, the use of modern educational technologies, etc.

Therefore, the formation of a teacher's skills in conducting a chemical experiment is a multifaceted process that requires systematic interaction between educational institutions, institutions for advanced training, and continuous self-education of the teacher.

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