APPLIED CHEMISTRY EXPERIMENT AS FACTOR OF INNOVATIVE EXPERIMENTAL AND METHODOLOGICAL TRAINING OF FUTURE CHEMISTRY TEACHERS

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Abstract: The goal of the article is to highlight the theoretical and methodological principles of using the applied chemical experiment as a factor of innovative experimental and methodical training of future Chemistry teachers. The main tasks of the investigation are determined according to the goal set. They are: 1) to reveal the essence of the applied experiment and innovative activity of future Chemistry teachers; 2) to substantiate the essence of the innovative methods of using the applied experiment while studying the discipline “Methods of Teaching Chemistry”; 3) to develop the methodical support of innovative methods of using the applied experiment; 4) to check experimentally the efficiency of the developed methods in training future Chemistry teachers. The research hypothesis is based on the assumption that using the applied chemical experiment, while studying the discipline “Methods of Teaching Chemistry”, will promote the efficiency of innovative experimental and methodical training of future Chemistry teachers. The research shows that using the various forms of the applied experiment has a significant impact on the quality of education and the level of students’ experimental skills.

Keywords: the applied chemical experiment, theoretical and methodical principles, innovative methods, the components of innovative methods, methodical support, students.

Introduction

The main goal of higher education in Ukraine in the conditions of its reforming is the training of a highly qualified teacher being competitive for labour market, oriented in the related fields of study, ready to continuous professional development. Therefore, a modern school requires the teacher, who is able to work creatively, to carry out innovative projects, to find the most rational and effective methods and forms of education process. An educational chemical experiment including the experiment of the applied nature has a considerable potential for the development of the creative abilities of future teachers.

The analysis of literature sources in the research problem shows that professional and experimental training of future Chemistry teachers is relevant. This problem is considered in the scientific works by national and foreign scientists, such as Beresnieva O.B., Gorieva I.V., Grabovy A.K., Zlotnikov Y.G., Kulenko O.A., Prybora N.A., Sevastianova O.V., etc. The scientists study the role of the experiment at the initial stage of training future Chemistry teachers, the continuity of their experimental training in a pedagogical higher school, the role of special courses and workshops in forming experimental skills, in forming experimental and methodical competences of future Chemistry teachers. However, the use of applied experiment in training future Chemistry teachers is studied insufficiently.

The problem of chemical experiment of the applied nature in the methods of teaching Chemistry is reflected in the works of native and foreign scientists, methodologists and Chemistry teachers, such as: Bespalov P.I., Volkov V.M., Volkova L.A., Voronenko T.V., Grabovy A.K., Ivakh T.S., Lashevska H.A., Rizvanov A.K., Yakovishyn L.O., etc. The researches consider the methods of applied experiment organization at Chemistry lessons and in extracurricular activity.

The research results help to make a conclusion that a way for improving experimental and methodical training of future Chemistry teachers is the use of innovative teaching methods (Surtaeva, 2013). To be able to use innovative teaching methods, the student, a future teacher, should be aware with them and act directly as a subject of teaching (Dychkivska, 2004).

Innovative pedagogical activity is investigated by Bohdanova I.M., Havrysh I.V., Dychkivska I.M., Pehota O.M., Ponimanska T.I. and others. The researchers consider modern approaches to the organization of pedagogical process at school and higher school, characterize innovative education technologies, and determine their didactic opportunities and organization peculiarities.

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Thus, the problem of using the applied experiment in experimental and methodical training of future Chemistry teachers is an urgent problem that is insufficiently studied and requires further investigation. The goal of the research is to determine the theoretical and methodical principles of innovative methods of using the applied chemical experiment in the experimental and methodical training of future Chemistry teachers.

**Method**

To achieve the goal set, we have used: 1) theoretical methods: the analysis of scientific and methodical literature to determine the state and development of the investigated problem; modeling and designing to develop methodical system and its educational and methodical implementation; 2) empirical methods: pedagogical experiment to test the efficiency of methodical system of using the applied experiment in training future Chemistry teachers; 3) statistical methods: the methods of statistical analysis of pedagogical experiment data.

Organizing the research we follow the assumption that forming experimental skills of future Chemistry teachers will be efficient if: 1) the essence of the applied experiment and innovative methods of its implementation into the education process in “Methods of Teaching Chemistry” discipline have been determined; 2) a model has been developed, and the stages of using the applied experiment in training future Chemistry teachers have been substantiated; 3) the methodical support of the research has been developed.

During the research we find that the applied chemical experiment is an experiment, during which the substances and materials of household, such as: food, medicines, substances for personal hygiene, washing and cleaning agents, household agents, are used (Grabovy, 2013).

The applied chemical experiment, like a traditional one, performs methodological, educational, training, developing, heuristic, correcting, generalizing, investigating, and stimulating functions in teaching Chemistry. One of the advantages of the applied experiment is the solution of the problem as to the deficit of chemical reagents, their availability and, primarily, safety.

The word “innovation” means renewal and change according the “Modern Dictionary of Foreign Words” (Skopenko and Tsymbaliuk, 2006). “Education Encyclopedia” points out that “innovation in education” is the process of creating and implementing ideas, ways, pedagogical and managing technologies to increase the indicators (levels) of achievements of educational structural components; there is a transformation of the system to qualitatively innovative stage (Kremen, 2013).

Dychkivska I.M. defines innovative pedagogical activity as a purposeful pedagogical activity focused on the change and development of educational process to achieve higher results, to acquire new knowledge, to form qualitatively different pedagogical practice (Dychkivska, 2004).

Therefore, we distinguish the following types of innovative activity as to the use of the applied experiment in the professional and methodical training of future Chemistry teachers: modeling of ecological problems; situational tasks; pedagogical projecting; prognostic tasks (Vasilieva and Kuznetsova, 2003; Dychkivska, 2004; Zhulkova, 2003; Pekhota, Kitenko and Liubarska, 2003; Sydorenko and Chuba, 2001).

We are going to describe the distinguished types of innovative activity as to the use of the applied experiment while learning the discipline of “Methods of Teaching Chemistry”.

I. **Modeling of Educational Chemical Experiment.** “Modern Dictionary of Foreign Words” points out that research modeling is the research method with that there is a change of a concrete research object (original) with another one, similar to it (model) (Skopenko and Tsymbaliuk, 2006).

“Education Encyclopedia” stresses that a model is a imaginary or materialized system that is reflected or reproduces a research object (natural or social) and is able to replace it in the way that its study gives definite information concerning this object (Kremen, 2008).

Models are divided into two classes: material and ideal. Material models involve those made of substances and materials. They are divided into static (immovable) and dynamic (active). Ideal models are divided into figurative, symbolic and thinking. Figurative models include pictures and schemes; symbolic – chemical formulas and equations; thinking – the idea of certain phenomena and processes (Naidan and Grabovy, 1998). Polosin V.S. considers educational chemical experiment to be material and ideal model as during teaching Chemistry the experiments (material models) are always accompanied with explanations in the form of chemical formulas and equations (symbolic models) (Tsvetkov, Ivanova and Polosin, 1981).

We are going to give an example of chemical experiment model. **Carbon model for industrial wastewater treatment.** The model highlights the industrial methods of environmental protection from the pollutants of anthropogenic nature. The technological processes of
wastewater treatment with adsorption method are modeled. Organic dyes and heavy metals salts are used as model compounds. Activated carbon (pharmacy pills) is chosen as adsorbent.

**Experiment 1. Absorption of Dyes with Activated Carbon.**

*Reagents and equipment:* activated carbon (pharmacy pills), magenta (an aqueous solution, w 1%), support with test tubes, glass rod, spatula, cleaner with water.

**Performance Technique**

Water of 2-3 cm$^2$ volume is poured to the test tube; 3-4 drops of magenta are added; the mixture of the tube is shaken. The liquid is colored in pink. Then a pill of activated carbon is added to the tube. The mixture is stirred with a glass rod and is left to settle. The discoloration of the solution is observed.

**Experiment 2. Adsorption of Colored Ions with Activated Carbon.**

*Reagents and equipment:* activated carbon (pharmacy pills), copper (II) sulfate (aqueous solution, c = 0.02 mol / l), potassium dichromate (aqueous solution, c = 0.02 mol / l) support with test tubes, glass stick, spatula.

**Performance Technique**

The solution of copper (II) sulfate with 1.5-2 cm$^3$ volume is poured to one test tube; the same volume of potassium dichromate solution is poured to the other one. A half of activated carbon pill is added to each test tube; the content of the tube is mixed with a glass stick. The mixtures are left to settle. The discoloration of the solutions is observed.

Students use the experiment while forming the "adsorption" concept in the theme of "Non-Metallic Elements and their Compounds", module "Methods of Studying the Theme of School Chemistry Course".

**II. Project Activity of Students.** "Great Explanatory Dictionary of Modern Ukrainian" considers "project" as the conceived plan of actions, intent, intention (Busel, 2005). Psychological and pedagogical literature points out that the term of "project" is the process of creation, development and implementation of business plan, as well as the product of this activity.

We share the views of scientists (Pekhota, Kiktenko and Liubarska, 2003) that project method is a training technology. As a training technology, it provides a certain sequence of stages and procedures that can be reproduced.

At the same time, constructive and productive activity of a personality that is aimed at solving vital problem, achieving final result in the process of goal-setting, planning and implementing a project, is called project activity (Kremen, 2008).

As a result of our research, the stages of project activity of future Chemistry teachers are distinguished: 1) primary – introducing a project theme to students; 2) search and analysis – the search of literature sources and their analysis by students; 3) practice – the description of a project by students; 4) the presentation of the prepared project.

The project is used at the laboratory classes in Methods of Teaching Chemistry while considering the problems of methods and techniques of an experiment in terms of obtaining and studying oxygen properties (the module of "Techniques and Methods of School Chemical Experiment").

**Theme:** Technique of Obtaining Oxygen from Applied Substances in the Laboratory.

**Goal:** On the basis of literature sources, to choose applied substances, from which oxygen can be obtained in the school conditions, an alternative to obtaining oxygen from potassium permanganate. This reagent is referred to precursors and, therefore, its use at school is prohibited.

**Experiment 1. Obtaining Oxygen from Hydrogen Peroxide.**

*Reagents and equipment:* hydrogen peroxide (aqueous solution w = 3%), manganese (IV) oxide (powder), lime water, laboratory support with foot, support with test tubes, plug with gas-tube, spatula, wood chip, matches, a beaker of water.

**Performance Technique**

A device for obtaining oxygen is constructed from the given parts and is tested for impermeability. The end of a gas-tube is immersed into the glass of water; the test tube is warmed by a hand. If the connection of the test tube, plug and gas-tube is hermetic, air bubbles will come out of the tube in a few seconds. If air does not come out of the tube, the parts of the device should be disconnected and then connected again. The test tube or the plug with a gas tube may be changed for other ones of bigger or smaller size.

Then hydrogen peroxide of 1.5-2 cm$^3$ volume is poured into the test tube that is attached vertically in the foot of the support; manganese (IV) oxide is added with a spatula. The test tube is
quickly closed with a plug with a gas-tube, the end of which is immersed into the test tube, the opening of which is approached upwards. The completeness of filling the test tube with oxygen is tested by using smoldering chip when placing it to the opening of the test tube.

Then smoldering chip is immersed into the test tube with oxygen. The chip is taken away from the test tube; a little of lime water is added there. The water becomes cloudy.

\[
2\text{H}_2\text{O}_2 \xrightarrow{\text{MnO}_2} 2\text{H}_2\text{O} + \text{O}_2 \uparrow \\
\text{CO}_2 + \text{Ca(OH)}_2 = \text{CaCO}_3 \downarrow + \text{H}_2\text{O}
\]

A solution of hydrogen peroxide can be prepared from hydrogen peroxide-urea pills, the solution of which is used for rinsing the mouth and throat at angina and stomatitis. Hydrogen peroxide-urea is white pills, easily soluble in water. One pill corresponds to 15 cm³ of the solution with mass fraction of 3% H₂O₂.

**III. Situational Tasks.** The analysis of literature sources shows that situational methods of teaching are widely used in the educational process of high and higher schools (Zhulkova, 2003; Sydorenko and Chuba, 2001). Experimental tasks of applied character are used in the research. The research results allow us to make a conclusion that experimental situational problems are the tasks that include the description of experimental applied problem situation, the answers to which can be obtained in the process of performing real and imaginary experiment.

We are going to give examples of situational experimental tasks used while learning the module of "Methods of Teaching Themes of School Chemistry Course".

1. "...She took out the ear one of the largest pearls...and... dropped the pearl in vinegar. There was silence; the confused guests, standing still, watched as beautiful pearl was slowly dissolving in strong vinegar. When no trace left from it, Cleopatra lifted the cup, rotating it and shaking vinegar, and drank it all to the last drop" (Haggard 1991).

**Questions for students.** 1. What is the didactic purpose of the passage from G.R. Haggard’s novel “Cleopatra”? 2. What is the composition of a pearl and vinegar? 3. Make a reaction equation referred to the passage.

2. Two housewives prepare for washing. The first housewife heats water to 60°C and soaks linens in it; the second housewife brings water to boiling, boils it for 5 minutes and then cools it to 60°C; then she starts washing. Whose linens will be washed better? What simple experiment can prove it and how can it be explained?

**Questions for students.** 1. What is the didactic purpose of the task? 2. What experiment can be performed with that?

3. You have a receptacle with liquid bleach at home; the instruction label is lost. The liquid has the smell of chlorine. You decide to soak linens in it without heating. What bucket will you choose if you have a bucket of galvanized tin, an enamel bucket of damaged enamel and a plastic bucket at your disposal?

**Questions for students.** 1. What is the didactic purpose of the task? What properties of products is their application based on?

**IV. Prognostic Task.** The method of theoretical prediction occupies an important place among the methods of chemical research (Kuznetsova, Garkunov and Yerygin, 1984). It is based on the prognostic function of a theory. This teaching method is based on the most important chemical notions, the main laws of chemistry, leading theories. They create the preconditions for predicting structure, composition, the properties of substances, their belonging to a certain class of compounds.

The research results allow us to draw a conclusion that prediction is logical operations directed to obtaining concrete result.

Learning prediction is considered on the example of solving experimental task.

**Task 1.** Prove empirically that vinegar composition includes ethanoic (acetic) acid.

**Solution**

Vinegar is a water solution of acetic acid with a mass fraction of substance 4-9%.

The electronic structure of acetic acid molecule makes it possible to detect the reaction centers:

1) hydroxyl group, Hydrogen atoms - acid properties due to the Hydrogen atom of the hydroxyl group;
2) carbonyl group, multiple bond - C = O - reducing properties (joining Hydrogen atoms in the place of double bond)
Acetic acid, CH\textsubscript{3}COOH shows general properties of acids: dissociates in aqueous solutions, acts on indicators, interacts with metals, bases, salts of weaker acids.

**Experiments with Vinegar.**

*Reagents and equipment:* vinegar (acetic acid aqueous solution, w = 4-9%), litmus (water-alcohol solution, w = 1%), sodium hydroxide (water solution w = 10%), sodium carbonate (aqueous solution, w = 10% ), zinc (granules), magenta sulphuric acid, magnesium (powder).

**Performance Technique**

**Experiment 1. Vinegar Action on Indicators.**

Vinegar of 1 cm\textsuperscript{3} volume is poured to the test tube; some drops of litmus indicator are added. The litmus has changed the color to red.

**Experiment 2. Interaction of Vinegar with Metals.**

1-2 granules of zinc are put to the test tube; and about 2 cm\textsuperscript{3} of vinegar is poured. Gassing of zinc bubbles is observed from the zinc surface.

\[
\text{Zn} + 2\text{CH}_3\text{COOH} = (\text{CH}_3\text{COO})_2\text{Zn} + \text{H}_2\uparrow
\]

\[
\text{Zn}^0 + 2\text{CH}_3\text{COOH} = 2\text{CH}_3\text{COO}^- + \text{Zn}^{2+} + \text{H}_2\uparrow
\]

**Experiment 3. Interaction of Vinegar with Alkali.**

About 1 cm\textsuperscript{3} of sodium hydroxide solution is poured to the test tube; some drops of phenolphthalein are added. The colour of the solution has become crimson. Vinegar is being added with small portions to the test tube until the solution becomes colourless.

\[
\text{NaOH} + \text{CH}_3\text{COOH} = \text{CH}_3\text{COONa} + \text{H}_2\text{O}
\]

\[
\text{OH}^- + \text{CH}_3\text{COOH} = \text{CH}_3\text{COO}^- + \text{H}_2\text{O}
\]

**Experiment 4. Interaction of Vinegar with Sodium Carbonate Solution.**

About 1 cm\textsuperscript{3} of sodium carbonate solution is poured to the test tube and the same volume of vinegar is added. “Boiling” of the liquid is observed.

\[
\text{Na}_2\text{CO}_3 + 2\text{CH}_3\text{COOH} = 2\text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2\uparrow
\]

\[
\text{CO}_3^{2-} + 2\text{CH}_3\text{COOH} = 2\text{CH}_3\text{COO}^- + \text{H}_2\text{O} + \text{CO}_2\uparrow
\]

**Experiment 5. Restoration of Acetic Acid.**

Vinegar with 2 cm\textsuperscript{3} volume is poured to the test tube; a little powder of metallic magnesium is added. The active interaction of the metal and solution being heated is observed.

\[
2\text{CH}_3\text{COOH} + \text{Mg} = (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2\uparrow
\]

\[
2\text{CH}_3\text{COOH} + \text{Mg} = 2\text{CH}_3\text{COO}^- + \text{Mg}^{2+} + \text{H}_2\uparrow
\]

When the metal reacts fully, the part of the obtained solution is poured to another test tube; some drops of magenta sulfurous acid are added to it. In 20-30 seconds, the solution is coloured in red. It proves that aldehyde is formed in the result of the reaction.

Magenta sulfurous acid may be added to vinegar; and it can prove that acid does not react with this reagent.

The research results allow us to distinguish the organization forms of the purposeful use of the applied chemical experiment while teaching “Methods of Teaching Chemistry” discipline: lectures, laboratory classes, individual tasks, independent work, and pedagogical practice. Such a choice is...
proved with the idea in the pedagogical literature concerning the fact that all together they contribute to providing the training of students to professional activity (Goncharenko, Oliynyk, Fedorenko, 2003).

Students get theoretical basis of the applied chemical experiment methods and techniques at the lectures in methods of teaching Chemistry, particularly, at the lectures of “School Chemical Experiment, its Organization Methods”. The peculiarity of using the demonstration applied experiment at the lectures Methods of Teaching Chemistry is that it: 1) is used as an element of illustration methods; 2) reveals the contents of two academic disciplines – School Course of Chemistry and Methods of Teaching Chemistry; 3) contributes the realization of certain didactic tasks – increasing the education efficiency in teaching Chemistry Methods and forming students’ skills concerning the applied experiment in teaching Chemistry in high schools.

The formation of students’ practical skills is implemented at the laboratory classes in Methods of Teaching Chemistry (“Techniques and Methods of School Chemical Experiment” module). Training methods include such stages: 1) determining demonstration, laboratory experiments, practical works, which can be performed using the applied substances, according to school program; 2) introducing experiment techniques according to methodical textbooks; 3) describing experiment techniques; 4) the preliminary performance of experiments.

The improvement of students’ practical skills is carried out at the laboratory classes in Methods of Teaching Chemistry (“Methods of Teaching School Chemistry Course Themes” module). Conducting the methodical analysis of school Chemistry course themes, the students determine the types of chemical experiment in a theme, its didactic purpose, the opportunity of using the applied experiment. Certain stages are followed. At the first stage, the students develop lesson summaries using the appropriate experiment. At the second stage, the students model a lesson in the subgroup of students. One student acts as a teacher, and the rest - as students. The teacher organizes the students’ cognitive activity. Then, the conducted lesson is discussed (Pometun and Pyrozhenko, 2004).

Extracurricular independent work complements the lectures and laboratory classes: the students deepen their knowledge in the theory and practice of the applied experiment, chose experiments with the use of the applied substance, develop lesson summaries of combining the applied experiment with the technologies of teaching Chemistry. Course papers deepen students’ knowledge as to the methods of using the applied experiment; develop the experiment techniques using the certain groups of applied substances.

Pedagogical practice contributes to the practical implementation of students' knowledge and skills in the methods of preparing and conducting the applied experiment at Chemistry lessons and extracurricular classes; the students study the experience of Chemistry teachers concerning the problem.

As a result, we have developed the methods model of using the applied experiment in the experimental and methodical training of future Chemistry teachers (Fig. 1).

Concerning the methods of students’ educational activity, active educational methods are used more often in the pedagogics of higher school. Sharing this view, activity method is in the basis of functioning experimental methods. Its implementation is aimed at forming future Chemistry teachers’ knowledge and skills in methods and techniques of the applied chemical experiment.

The implementation of experimental methods of training future Chemistry teachers is characterized with the complex application of education methods. Thus, while training students to the use of the applied experiment in teaching Chemistry at high school, such groups of methods are used: 1) general and logical (analysis, synthesis, comparison, induction, analogy, generalization); 2) visual (illustration, demonstration, modeling); 3) practical (testing technique of performing experiments, simulation games, pedagogical projecting) (Goncharenko, Oliynyk and Fedorenko, 2003).

According to Ivanova R.G. (Tsvetkov, Ivanova, Polosin, 1981), problematic character of teaching Chemistry is implemented through different variants depending on the contents of educational material and students’ preparedness: 1) problematic presentation of the material by a teacher accord-
Methods of using the applied chemical experiment in experimental and methodical training of future Chemistry teachers

**Approaches:**
- system,
- activity,
- competence,
- personality development

**Didactic principles:**
- of science, system and consistence,
- consciousness, activity and independence, visibility, solidity, connection of education and practical reality, unity of educational, developmental and training functions of learning

**Organization forms:**
- lectures, laboratory classes, independent work, research work, pedagogical practice

**Educational methods and means:**
- general and logic, verbal, visual, practical; educational and methodical set; chemical reagents and equipment

**Educational activity of students:**
- frontal, individual, group

Methods components of using the applied experiment in experimental and methodical training of future Chemistry teachers:
- the applied chemical experiment;
- innovative methods of using and experiment;
- professional focus of the educational process;
- modular training and rating evaluation of students’ educational achievements;
- students’ independent work in experiment methods and techniques;
- educational and methodical set in methods and techniques of the applied chemical experiment.

Implementation stages of the use methods of the applied experiment in training future Chemistry teachers

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Contents</th>
<th>Organization and activity</th>
<th>Final</th>
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Diagnostics of learning outcomes
- observation, control papers, tests

Expected result:
- the teacher who is able to organize and conduct the applied chemical experiment in a high school

Fig. 1. Model of Methods for Using Applied Chemical Experiment in Experimental and Methodical Training of Future Chemistry Teachers

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ing to the implementation of explanation and illustrative method; 2) joint solution of a problem, when students find the confirmation of the hypothesis in the process of heuristic conversation or practice according to a partly search method; 3) students are given the opportunity to formulate the hypothesis independently, to find the ways of solving it and to reach conclusions according to research method. Considering this (Grabovy, 2015), we distinguish such types of the applied experiment: illustration, problem and research. Illustration experiment is an experiment that is preceded by writing the reaction equation, and the experiment itself proves the correctness of the facts informed by a teacher.

Problem experiment is an experiment which helps to create problematic situation encouraging pupils to search the reasons of the observed phenomena.

Research experiment is an experiment which helps pupils to solve a cognitive task independently. While conducting an experiment, pupils observe, analyze the obtained data, explain them from the theoretical point of view and formulate the conclusion.

The method of theoretical prediction based on the prognostic function of theoretical knowledge occupies an important place among the methods of students’ educational activity (Kuznetsova, Garkunov and Yerygin, 1984). Considering this, we distinguish the structure of students’ prognostic activity: 1) introduction of the task contents; 2) the systematization of the facts, phenomena and processes; 3) the formulation of hypothesis; 4) experiment modeling to test hypothesis; 5) conducting an experiment; 6) making a conclusion.

Learning tools of the research are curricula, Chemistry textbooks for high schools, textbooks in the methods of teaching Chemistry, tables in chemical experiment techniques, didactic materials, technical tools of education, laboratory glassware, reagents and equipment.

Training a future teacher for organizing and conducting the applied chemical experiment is implemented according to didactic educational principles in a higher school: principle of science, system and consistence, consciousness, activity and independence, visibility, solidity, connection of education and practical reality, unity of educational, developmental and training functions of learning (Goncharenko, Oliinyk and Fedorenko, 2003).

The most efficient approaches that promote the formation of future teachers’ experimental and methodical skills are determined to be competence approach, system approach and personality development approach (Davydov, 1991; Ovcharuk, 2004). Competence approach is aimed at forming skills to solve experimental problem situations. System approach provides interrelation and interaction of educational process and methods of teaching Chemistry. Activity approach enhances professional orientation of experimental methods of teaching students. Professional orientation of education process implies such an organization of education, when students perform an activity that is similar to the professional activity of a Chemistry teacher of a high school. Personality development approach means considering the individual peculiarities of students, their abilities, interests, needs to achieve results in organizing and conducting the applied chemical experiment in high schools.

The process of forming the experimental and methodical skills of future Chemistry teachers is carried out gradually including four stages: analytical, contents, organization and activity, and final stage. At every stage, the activity of a teacher and students is determined with a goal, contents, conditions and the expected result. Analysis stage implies the analysis of literature sources in the problem of experimental training of future Chemistry teachers, the theory and practice of the applied experiment, and innovative educational methods. Contents stage involves the development of innovative methods of using the applied experiment in training future Chemistry teachers, education models and its methodical support. Organization and activity stage implies attracting students to the activity similar to the activity of a Chemistry teacher concerning the organization and conducting the applied chemical experiment in high schools. The final stage means checking the efficiency of the developed methods of using the applied experiment in teaching Chemistry in high schools.

Results

An index of expressing experimental skills of future Chemistry teachers is used as a criterion of estimating the efficiency of the developed methods. The research is conducted according to the known methods of Kuzmina N.V. (1970) using the cards of students’ self-estimation. Answers are estimated according to five-step scale: high, sufficient, intermediate, low level of skill expression and the lack of skills. Conditional values from +1 to -1: +1(a) high level of skill expression, +0,5(a) sufficient level of skill expression, -0,5(c) intermediate level of skill expression, -1(d) low level of skill expression and 0(e) – lack of skills are given to the different levels of skill expression. Adding the obtained data, the index of future Chemistry teachers’ skill expression is determined:
The index of skill expression to use the applied experiment; \( a, b, c, d, e \) – algebraic sum of skill expression; \( N \) – general number of the surveyed.

The study is conducted using the method of small sample (25, p.64).

Results of the study are shown in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>#</th>
<th>Skills</th>
<th>Conditional values for determining the indices of expressing students’ skills</th>
<th>Indices of skill expression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( N )</td>
<td>( a ) (+1)</td>
</tr>
<tr>
<td>1</td>
<td>Following safety rules while conducting an experiment</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>Ability to plan and chose an experiment</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Ability to demonstrate experiments</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Ability to organize pupils’ experiment</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>Ability to analyze the conducted experiment</td>
<td>25</td>
<td>19</td>
</tr>
</tbody>
</table>

The results of experimental study (Table 1) show that indices of expressing students’ skills concerning the organization and realization of the applied chemical experiment in teaching Chemistry at high schools are rather high, ranging 0.82-0.9. The students have certain difficulties in the organization of pupils’ experiment and in the analysis of the conducted experiment (reflection).

### Discussion

The article describes the theoretical and methodological foundations of using the applied chemical experiment in the experimental and methodical training of future Chemistry teachers.

Theoretical analysis of literature sources concerning the problem of study shows that the problem of using the applied chemical experiment in the experimental and methodical training of future Chemistry teachers is urgent but insufficiently developed.

The results of the study find out that the applied chemical experiment is an experiment, during which household substances and materials are used: food, medicines, matter of personal hygiene, washing and cleaning agents, household agents. The types of innovative activity concerning the applied experiment in the professional and methodical training of future Chemistry teachers, such as, modeling chemical problems, situation tasks, pedagogical projecting, and prognostic tasks, are distinguished.

The method model of using the applied chemical experiment in the experimental and methodical training of future Chemistry teachers is developed.

Lectures, laboratory classes, independent and educational research work, the pedagogical practice of students in “Methods of Teaching Chemistry” discipline are chosen as forms of the purposeful use of the applied experiment.

The efficient impact of innovative methods of using the applied experiment on the formation of experimental and methodical skills of future Chemistry teachers is demonstrated.

The perspective of further development of the main ideas of the research is the study of readiness levels of future Chemistry teachers to organizing and conducting the applied experiment in teaching Chemistry at high schools.

### References


