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The study of the application of experimental tasks based on improving the functional literacy of students in elective chemistry classes

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Annotation. This article is devoted to studying of the application of experimental tasks to improve the functional literacy of students in elective chemistry classes. Functional literacy is an important factor in developing students' ability to apply their knowledge in everyday life, critical thinking skills, and independent decision-making. The article proposed methodological approaches to improving functional literacy and discussed the role of practical classes in chemistry. The study provided specific examples of tasks that contribute to developing students' subject and general competencies. In addition, the article analyzes the effectiveness of using interactive methods for functional literacy formation, linking chemical experiments with life situations. The results of the study showed that experimental tasks contribute to improving the ability of students to apply theoretical knowledge in practice. The author offers specific methodological recommendations to increase students' interest in classes, develop creative abilities, and form a positive attitude toward science. This article is intended for chemistry teachers, educational researchers, and professionals interested in improving students' functional literacy.

Keywords: functional literacy, chemistry lessons, elective classes, experimental tasks, methods, patterns of chemical reactions, situational issues.

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Introduction

Functional literacy is an important aspect of the modern educational process, as it allows students not only to assimilate and apply knowledge but also to adapt to the rapidly changing world. Elective chemistry lessons, unlike standard ones, provide unique opportunities for in-depth study of the subject and the development of basic skills necessary for successful life in society [1]. The impact of chemistry elective classes on functional literacy includes not only subject knowledge but also the ability to apply it. Elective classes can effectively develop this process through various teaching methods and forms, such as project activities, research work, experiments, and practical exercises. For example, students can make and conduct experiments to study the properties of objects, which helps them not only to consolidate theoretical knowledge but also to develop practical skills.

During the study, the experimental tasks application in teaching chemistry particularly contributes to the development of students functional literacy. The authors point out that such tasks increase students' interest in the subject and improve their ability to

apply theoretical knowledge in practice during the solving of modern problems [2]. It is studied that various functional literacy tasks, in addition to improving the learners' knowledge quality, allow them to develop cognitive and creative skills. In addition, it is shown by illustrative examples that the level structure of such tasks creates conditions for taking into account the different students abilities and their development on an individual learning trajectory, and that this approach is used in combination with the criterion-based assessment system of learning achievements, as it allows to objectively and assess the students learning outcomes. The tasks presented in the article are an important tool in the formation of students functional literacy. They, combined with theory and practice, helped to arouse students' interest in science, as well as to develop their logical and critical thinking. Based on this, we believe it is possible to understand how important experimental tasks for the formation of students functional literacy [2].

Let us dwell on the effectiveness of using experimental tasks in elective classes and their inclusion in the curriculum. [3] The article substantiates the purpose of the development process analysis of functional literacy and its natural-scientific literacy in chemistry lessons in the conditions of shortened curricula implementation in specialized general education schools of the Republic of Kazakhstan. Pedagogical justifications and methods for the shortened time program are considered. Putting forward similar issues in our country, the importance of elective classes can be explained [3].

The main components of the experiential learning will be analyzed as follows:

1. Practical interaction: students perform tasks that require the application of theoretical knowledge in a specific situation.
2. Control and analysis: students learn to control the results of their actions, analyze them, and draw conclusions.
3. Feedback: an important aspect is receiving feedback from the teacher and peers, which helps to improve the understanding of the material [4].

Experimental learning ensures that students are actively involved in the learning process. Students become active participants instead of passively absorbing information by conducting experiments, investigations, and applying their knowledge in practice. This creates an interesting and stimulating learning environment. Students participating in the educational process show great interest and initiative, which contributes to their academic performance [5].

Materials and methods

The materials for the work served as:

- works of domestic and foreign teachers on this topic;
- school elective course in chemistry;
- developed experimental tasks for the formation of students functional literacy.

The following research methods were used in the study to determine the effectiveness of the experimental tasks aimed at improving students' functional literacy:

1. Method of pedagogical experiment

The pedagogical experimentation importance:

- scientific accuracy – the new methodology effectiveness is confirmed by actual data.
- objectivity – compares the results of the control and experimental groups and identifies differences.
- practical application-if the method is effective, it can be widely used. This method is a key tool in your study that helped to prove the impact of experimental tasks on the development of students' functional literacy [6].

By application in the study can be grouped into 3 stages:

Stage 1. At the preparatory stage, the aim and objectives of the study were determined, 10th grade students (24 children) participating in the experiment were selected. The students were divided into 2 groups. While experimental tasks aimed at the development of functional literacy were used for the students of the experimental group, the control group was taught using traditional teaching methods.

Stage 2. For the main stage (experimental work), the same theoretical training was given to both groups. While the control group was given simple everyday tasks and problems, the experimental group was taught experimental tasks such as situational tasks, laboratory work, creative tasks to understand the chemical reactions patterns. After the sessions, students' activity, interest, and task completion quality were monitored.

Stage 3. Before and after the experiment on the final stage (analyzing the results) test works were conducted for both groups. Test results were compared, the experimental tasks effectiveness was evaluated, interview and survey methods were used to find out students' opinions.

2. Comparative analysis method

It helps to determine how the studied phenomenon depends on various factors:

- allows to prove the effectiveness of the research with the help of quantitative data;
- creates conditions for objective analysis of research results, helps to demonstrate the effectiveness of experimental tasks with specific evidence [7].

The method of comparative analysis was used to compare the learning achievements of the experimental and control groups. An introductory and final control work was conducted to determine the level of knowledge of each group.

3. The method of using experimental tasks – creative *tasks* and *experiments* to solve experimental problems in chemistry are aimed at developing students' abilities for independent thinking, creativity and research. Such tasks go beyond standard laboratory work and require students not only to follow instructions precisely, but also to develop hypotheses, choose methods and explain results independently. As a result of creative assignments, students develop not only thematic competencies but also important skills such as planning, data analysis, and teamwork [8].

In the lessons of this method, students were given situational tasks, laboratory work and practical assignments. These tasks were designed to relate the patterns of chemical reactions to real-life situations.

4. The advantage of using the *control and interview method* is that it helps to objectively assess the real learning process in real time [9].

In order to assess the level of students' mastering of educational material using this method, their activity and interest in performing tasks were monitored during the lesson.

These methods help to diversify the learning process and increase students' motivation to learn chemistry through active participation in experimental activities.

Experimental tasks should be organized to gradually increase the functional literacy level. As for the task project structure, it is necessary to choose the task type. In our case, experimental tasks include *situational tasks, creative tasks, and laboratory tasks*. As for the complexity gradient, moving from the basic task of testing basic knowledge to more complex multilevel tasks that require gradual generalization and evaluation. Perhaps we are also better off keeping relevance in context, using a specific plan that makes the work relevant, and requiring a combination of chemistry with everyday practice.

The methodology for constructing experimental assignments incorporates a structured approach that combines a variety of activities, specific educational objectives, and real-world relevance. By adding a variety of activities to a detailed answer guide, teachers can not only improve functional illiteracy but also create a learning environment that prepares students for the practical application of chemistry.

Results

One of the main goals was to organize the educational process of elective chemistry lessons aimed at the formation and improvement of students' functional literacy abilities. Using these techniques, we compiled a series of experimental tasks and their correct answers to improve students' functional literacy in chemistry and worked on integration into the plans of elective lessons. A brief elective lesson plan and an elective lesson plan for 10th grade on the topic “The regularities of chemical reactions” were developed as experimental tasks to help improve students' functional literacy. To study the effectiveness of the work done, the following work was carried out:

During the research on the effectiveness of the tasks used in the lessons of the elective course for the development of functional literacy of students in chemistry, 24 children in the 10th grade were obtained. We divided the students of this class equally into 2 groups and considered the first group as *a research group* and the second group as *a control group*. Both groups were given the same theoretical training followed by additional training. The control group was given simple daily assignments and reports. The research group was given elective course lessons (with experimental assignments).

The theme of the elective class: «The regularities of chemical reactions».

The course objective is to improve students' functional literacy in chemistry through experimental assignments and problem-solving.

1. To develop knowledge: teach to study the basic regularities of chemical reactions and to determine the conditions affecting the reactions course.
2. To develop logical thinking, the ability to discuss experimental data and apply knowledge in practice.
3. 3. To develop as a person: develop responsibility, accuracy, and teamwork skills.

Topics and lesson plan:

Subtopic 1: the main types of chemical reactions and their classification.

- theoretical introduction to the reactions classification;
- practical work: classification of chemical reactions examples by types.

Subtopic 2: factors affecting the reaction (catalysts, temperature, pressure)

- discussion of the different factors affecting the rate and direction of reactions;
- experiment: studying the catalyst effect on the decomposition of hydrogen peroxide.

Subtopic 3: redox reactions

- repetition of redox reactions;
- lab work: identifying the oxidizing agent and reducing agent in a reaction.

Subtopic 4: patterns of energy change in chemical reactions

- study of exothermic and endothermic reactions;
- experiment: control of temperature effect on solubility of different salts in water.

Table 1. Experimental tasks and laboratory work

№	Laboratory task	Questions and answers	
		Question	Answer
1	Conduct a neutralization reaction of sodium hydroxide with hydrochloric acid and determine the heat effect reaction. In the work process, it is necessary to determine the mass of solutions and measure the temperature before and after the reaction. Calculate the heat effect by the formula Q = mcΔT.	1. What role does temperature play in a reaction?	Temperature affects the rate of a reaction and can change its heat effect.
		2. Why is a neutralization reaction exothermic?	During a neutralization reaction, energy is released as heat as stable products are formed.
2	Study of the catalyst effect on the rate of decomposition of hydrogen peroxide. Comparison of the compound decomposition time in the process with and without catalyst.	1. What function does a catalyst perform?	The catalyst does not participate in the reaction, but it speeds up the reaction.
		2. Does the addition of a catalyst change the final product size?	No, the catalyst does not affect the production of the product, only the rate.

Tasks and solutions for calculation:

Task 1. If the heat effect is 890 kJ/mol, calculate the amount of heat released by the combustion of 12 g of methane.

Solution: Molar mass of CH4 = 16 g/mol. Methane substance content: n = 12 g / 16 g/mol = 0.75 mol. Q = 0.75 mol × 890 kJ/mol = 667.5 kJ.

Answer: 667.5 kJ.

Task 2. If it is known that 200 kJ of heat is released during the neutralization reaction, determine the amount of substance with a mole measure. The heat effect of the reaction is 114 kJ/mol.

Solution: n = Q / ΔH = 200 kJ / 114 kJ/mol ≈ 1.75 mol.

Answer: 1.75 mol.

Task 3. Determine the mass of zinc required to produce 5 liters of hydrogen for the reaction Zn + 2HCl → ZnCl2 + H2.

Solution: V(H2) = 5 l, Vm = 22.4 l/mol, n(H2) = 5 l / 22.4 l/mol ≈ 0.223 mol. The mass of Zn = 0.

Answer: 14.5 g.

223 mol × 65 g/mol ≈ 14.5 g.

Table 2. Situation questions and correct answers to the topic

No.	Situation Question	Answer
1	In the laboratory, it was found that the decomposition reaction of hydrogen peroxide was too slow. What steps could be taken to speed up the reaction? What methods of speeding up the reaction would you recommend?	Add a catalyst, such as manganese (IV) oxide, or increase the temperature.

2	During an experiment to dissolve salt in water, a significant increase in the temperature of the solution is observed. How can you explain this effect?	It is an exothermic reaction in which energy is released as heat.
3	An ammonia leak has occurred in a factory. The gas needs to be neutralized to avoid contamination. What substances can be used to neutralize ammonia?	Acidic solutions such as hydrochloric acid solution can be used to form ammonium chloride.
4	Too much excess acid was used in the reaction to produce hydrogen from zinc and sulfuric acid. How does this affect the results of the experiment?	The amount of hydrogen produced does not change because the amount of hydrogen produced is determined by the amount of zinc, but the reaction proceeds faster.
5	When magnesium is experienced burning in oxygen, a strong glow is observed and a white powder is formed. What is this powder and why does it glow?	The powder is magnesium oxide (MgO). The glow is due to the high energy released during the exothermic reaction.
6	A student noticed that when ammonium nitrate dissolves in water, the temperature of the solution drops dramatically. What reactions does this process belong to and what does it mean from an energy point of view?	This is an endothermic reaction in which heat is absorbed from the environment.
7	During a laboratory experiment, the interaction of salt with acid resulted in the release of strong-smelling gases. What gas might be emitted and how can it be identified?	Hydrogen sulfide (H2S) can be emitted. It can be identified by the pungent odor of rotten eggs and the reaction with lead acetate solution, which gives a black precipitate.
8	An experiment was performed to extract the precipitate from the interaction of the two solutions. However, during repeated experiments, the precipitate did not fall out. What could be the reasons for the lack of precipitation?	Perhaps the concentration of the solutions was too low, or the reaction was hindered by extraneous impurities.

After full explanatory work with analysis and discussion of experimental tasks for the above-mentioned elective courses, students of group 2 were given questionnaires and test tasks for the same thematic summarization.

As shown in the study results (Figure 1), it was found by the survey that the students of group 2 understood the topic at 30% – completely, 45% – at the average level, 25% below average, and showed low (65%) result in test tasks made up of test tasks based on situational tasks.

The 1st research group students according to the questionnaire results found that 85% – completely and the remaining 15% – were at the average level and showed high results (90%) in the performance of test tasks composed of test tasks based on situational tasks.

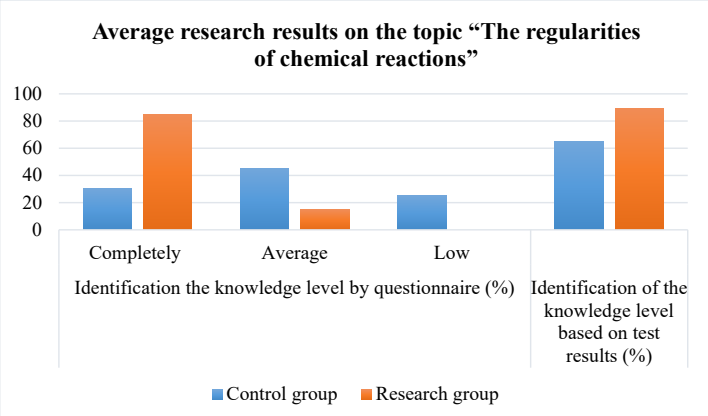

Figure 1. Average research results on the topic “The regularities of chemical reactions”

Discussion

The research results analysis clearly showed the effectiveness of using situational tasks to improve students' functional literacy. Based on the results of the survey and test, significant differences in the knowledge level assimilation by each group were revealed.

Study group 1 proved the teaching method effectiveness based on situational tasks. 85% of students in this group fully grasped the topic and 15% understood it at an average level. In addition, they showed a high score (90%) on test tasks. These indicators show that situational tasks had a positive impact on the development of students' thinking, problem-solving skills, and functional literacy. The content and structure of the tasks presented in the learning process facilitated the integration of students' knowledge with experience and deep understanding of the topic.

On the contrary, the results of research group 2 indicate the absence of such an approach. Only 30% of the students in this group fully grasped the topic, 45% understood it at an intermediate level, and 25% at an intermediate level. At the same time, the results of test tasks (65%) showed a low level of skills in applying their knowledge in practice. This indicates that the traditional teaching method is not sufficient for the development of students' functional literacy.

Analyzing the results, there are several important aspects of the methodologies used in the study that contribute to functional literacy. First, situational tasks develop students' analytical and logical thinking skills and adapt them to solving real-life problems. Second, these tasks promote students' interest in the subject matter and increase their engagement during class.

The study results are consistent with previous studies. Also, in other studies on the use of tasks aimed at developing functional literacy (e.g., Pisa and Tims' studies), problem-based and hands-on teaching methods have been shown to have a positive effect on improving students' proficiency. These studies found that the use of case-based tasks not only improved students' knowledge but also enabled them to develop their life skills [10,11].

In [12-14], the authors also used situational tasks and showed their effectiveness in improving the functional literacy. Thus, our results confirm and complement existing research, and further prove the importance of situational tasks for improving functional

literacy. Such tasks help to prepare students for real-life situations and apply the acquired knowledge in practice. Therefore, a widespread application of the Chemistry teaching method based on situational tasks is suggested in schools. This methodology, in addition to increasing the students' knowledge level, allows them to adapt to life and increase their interest in the subject.

Conclusion

It has been verified that the experimental tasks application in elective chemistry courses is an effective tool for developing students' functional literacy. Such tasks assist in developing critical thinking, data analysis, and problem-solving skills, which are important components of functional literacy. As the practice of these tasks shows, they significantly increase students' interest in the subject, help them to better understand chemical concepts, and develop practical skills necessary for their successful application in everyday life. Thus, the application of experimental tasks is aimed not only at the development of knowledge but also at the formation of skills that contribute to the students comprehensive development, which is especially important in the modern educational process conditions.

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Аңдатпа. Бұл мақала химия пәнінен элективті сабақтарда оқушылардың функционалдық сауаттылығын арттыру мақсатында эксперименттік тапсырмалардың қолданылуын зерттеуге арналған. Функционалдық сауаттылық – оқушылардың алған білімдерін күнделікті өмірде қолдану қабілеті, сын тұрғысынан ойлау, өздігінен шешім қабылдау дағдыларын дамытудағы маңызды фактор. Мақалада функционалдық сауаттылықты арттырудың әдістемелік тәсілдері ұсынылып, химия пәнінде тәжірибелік сабақтардың рөлі талқыланды. Зерттеу барысында оқушылардың пәндік және жалпы біліктіліктерін дамытуға ықпал ететін нақты тапсырмалар үлгілері берілді. Сонымен қатар, мақалада функционалдық сауаттылықты қалыптастыру үшін интерактивті әдістерді қолдану, химиялық эксперименттерді өмірлік жағдайлармен байланыстырудың тиімділігі талданған. Зерттеу нәтижелері эксперименттік тапсырмалардың оқушылардың теориялық білімін тәжірибеде қолдану қабілетін жақсартуға ықпал ететінін көрсетті. Автор оқушылардың сабаққа қызығушылығын арттыру, шығармашылық қабілеттерін дамыту және ғылымға деген оң көзқарасын қалыптастыру мақсатында нақты әдістемелік ұсыныстар ұсынады.

Бұл мақала химия пәні мұғалімдеріне, білім беру саласындағы зерттеушілерге және оқушылардың функционалдық сауаттылығын арттыруға мүдделі мамандарға арналған.

Кілтті сөздер: функционалдық сауаттылық, химия сабақтары, элективті сабақтар, эксперименттік тапсырмалар, әдістемелер, химиялық реакциялардың заңдылықтары, ситуациялық сұрақ.

Изучение применения экспериментальных заданий, основанных на повышении функциональной грамотности учащихся на элективных занятиях по химии

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Аннотация: Данная статья посвящена изучению применения экспериментальных заданий с целью повышения функциональной грамотности учащихся на элективных занятиях по химии. Функциональная грамотность-важный фактор в развитии у учащихся умения применять полученные знания в повседневной жизни, навыков критического мышления, самостоятельного принятия решений. В статье были предложены методические подходы к повышению функциональной грамотности, обсуждена роль практических занятий по химии. В ходе исследования были даны конкретные примеры заданий, способствующих развитию предметных и общих компетенций учащихся. Кроме того, в статье проанализирована эффективность использования интерактивных методов для формирования функциональной грамотности, связывания химических экспериментов с жизненными ситуациями. Результаты исследования показали, что экспериментальные задания способствуют улучшению способности учащихся применять теоретические знания на практике. Автор предлагает конкретные методические рекомендации с целью повышения интереса учащихся к занятиям, развития творческих способностей и формирования позитивного отношения к науке. Эта статья предназначена для учителей химии, исследователей в области образования и специалистов, заинтересованных в повышении функциональной грамотности учащихся.

Ключевые слова: функциональная грамотность, уроки химии, элективные занятия, экспериментальные задания, методики, закономерности химических реакций, ситуационный вопрос.

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