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DEVELOPING FUNCTIONAL LITERACY AND LOGICAL THINKING IN CHEMISTRY EDUCATION

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Abstract

Objective:This article explores the integration of functional literacy and logical reasoning strategies into secondary chemistry education. The study aims to determine how modern pedagogical methods can enhance students' ability to apply chemical knowledge to real-world problems and prepare them for international assessment frameworks. Method:The research employed a qualitative methodology based on cognitive pedagogy and constructivist learning theory. It utilized theoretical analysis, classroom-based experimentation, and diagnostic assessments. Interactive teaching tools such as graphic organizers, heuristic techniques, laboratory experiments, and Bloom's taxonomy-based test formats were implemented to evaluate student progress. Results:Findings reveal that the application of functional literacy techniques significantly improves students' analytical skills, practical competence in laboratory tasks, and understanding of both open and closed test formats. Students demonstrated increased motivation, more accurate use of chemical concepts in practical contexts, and enhanced capacity for independent learning and scientific inquiry. Novelty:Unlike previous studies that focus solely on subject knowledge acquisition, this research emphasizes the integration of meta-subject competencies—such as logical reasoning and reading literacy—within chemistry education. It offers a holistic framework for cultivating students' intellectual engagement and international readiness through functional, interactive pedagogy.

Keywords: Chemistry education, functional literacy, logical thinking, interactive methods, experiment, teaching methodology, practical approach, learning process, innovative pedagogy, problem-based learning.

Introduction

This study aims to analyze and evaluate methods for developing functional literacy and logical approaches in chemistry education. As its methodological foundation, it relies on cognitive pedagogy, constructivist theory, and competency-based approaches. The research utilized theoretical analysis, experimental studies, and diagnostic evaluation methods.

A.A. Leontiev once stated: "If formal literacy means acquiring reading skills and abilities, then functional literacy refers to the ability to freely use these skills to extract, comprehend, analyze, and modify information from real texts." [1-2]

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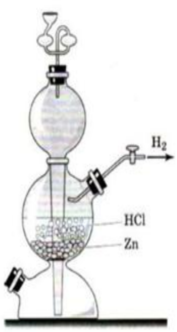
In the current educational context, it is essential to enhance students' cognitive engagement, improve the quality of teaching, and increase learning effectiveness by utilizing innovative forms of education. Nowadays, such innovative forms include educational games, problem-based learning, interactive methods, modular-credit systems, distance education, blended learning, and skills-based lessons.
In educational institutions of the Republic, the following widely used technologies are employed to organize interactive learning:

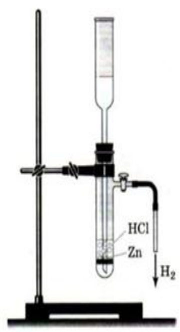
Interactive methods: case studies, blitz polling, modeling, creative tasks, value judgments, planning, and dialogical methods.

Strategies: brainstorming, boomerang, gallery walk, zigzag, step-by-step, debates, rotation, T-charts, and snowball techniques.

Graphic organizers: fishbone diagrams, B/B/B tables, conceptual tables, Venn diagrams, INSERT, cluster maps, "Why?" and "How?" structures. [1-2]
During the process of completing the task, students read and comprehend the question, develop the ability to fully understand its content, identify ambiguities within the task, and improve their logical reasoning regarding whether the question is of a closed-test format.
Information related to the subject of chemistry is studied, and assignments are completed based on relevant topic-specific data. For example: the production of hydrogen, its physical and chemical properties, and its applications.
The valency of hydrogen remains constant and is always equal to one. Because hydrogen's valency does not change, it serves as a reference point for determining the valency of other elements.
In laboratory conditions, hydrogen is obtained through the reaction of zinc with hydrochloric acid:
Hydrogen can be obtained in laboratory settings through the reaction of zinc with hydrochloric acid:
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
Other methods of hydrogen production include:

1. Electrolysis of water:
   $2H_2O \rightarrow 2H_2 + O_2$
2. Steam reforming of methane:
   $CH_4 + H_2O \rightarrow CO + 3H_2 \quad \Delta H = +206$ kJ
   (This reaction is carried out at 425–450°C in the presence of a nickel catalyst.)
3. Water-gas shift reaction:
   $CO + H_2O \rightarrow CO_2 + H_2 \quad \Delta H = -40$ kJ
   (This reaction is conducted at 425–450°C with an Fe_2O_3 catalyst.)





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After explaining the methods of oxygen production during the chemistry lesson, the teacher asked the following questions to assess students' understanding of the topic. [2–3]

1st Question:

In binary compounds composed of hydrogen and one other element, what does the subscript number of hydrogen represent? Think carefully and write your answer in the following lines.

Answer: ____

2nd Question:

Identify the chemical reaction by which hydrogen is obtained under laboratory conditions and name the chemical apparatus used in this experiment. Think carefully and write your answer in the following lines.

Answer: ____

3rd Question:

Determine the approximate percentage composition of hydrogen isotopes in light water, heavy water, and superheavy water. Think carefully and write your answer in the following lines.

Answer: ____

4th Question:

Which isotopes of hydrogen may be present in the most abundant compound found in nature (in liquid, gas, and solid states)? Think carefully and write your answer in the following lines.

Answer: ____

5th Question:

Fill in the table below by confirming whether the given statements are true or false using the (+) sign:

Statement	**True (+)**	**False (+)**
Iron rusts when in contact with water.		
All naturally occurring water consists solely of light water.		
When water evaporates it forms clouds; when condensed, it falls as rain, and vice versa.		
Hydrogen is the cheapest fuel when used as an energy source.		
Hydrogen is used industrially to produce ammonia, which in turn is used for fertilizers.		

6th Question:

The image below presents chemical experiments demonstrating laboratory and industrial methods for hydrogen production. [1–5]

Task: Describe the chemical processes illustrated by the author in the image. Identify the substances used in each chemical experiment and write the corresponding chemical reaction equations in the lines provided below.

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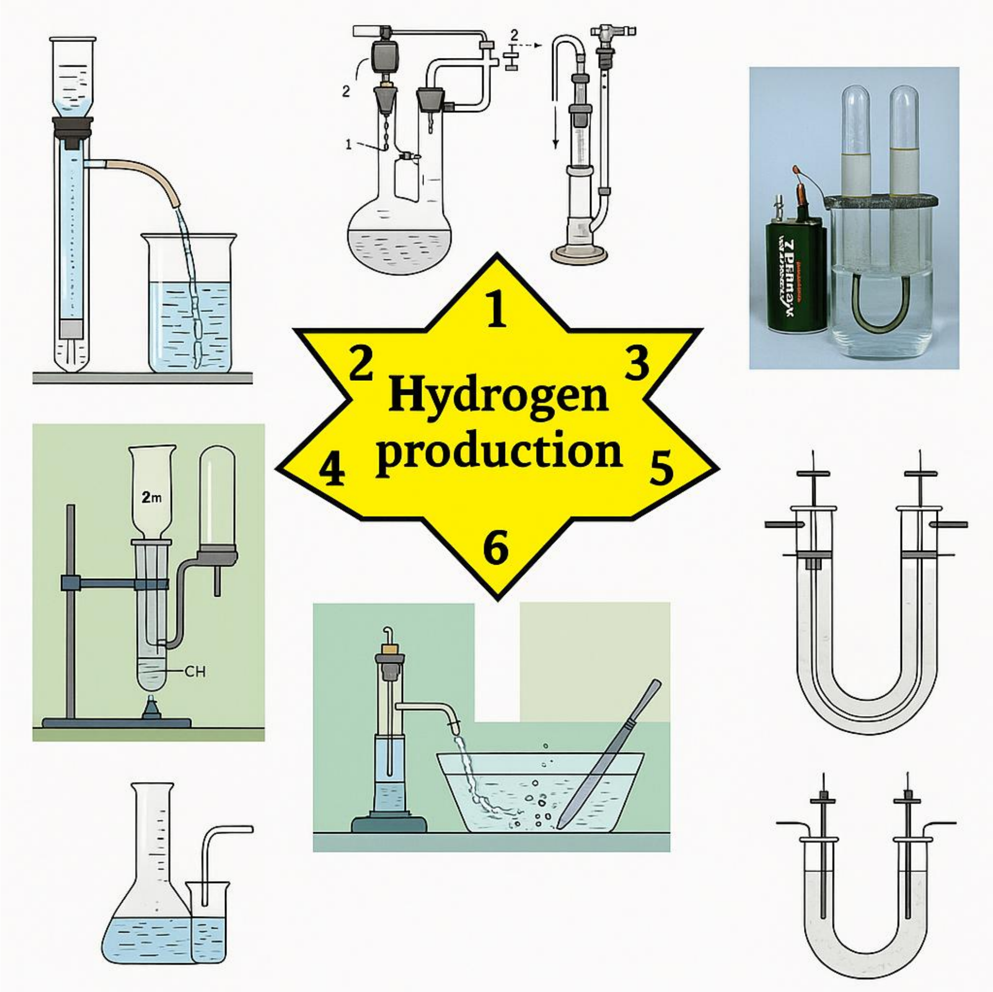

1st Experiment	
2nd Experiment	
3rd Experiment	
4th Experiment	
5th Experiment	
6th Experiment	

The Role of Meta-Subject Competencies and Functional Literacy in Chemistry Education

One of the most important components of the content of education is its universality, which is reflected through “meta-subject” skills. It is important to emphasize that these core competencies do not contradict traditional subject-based knowledge. However, it is evident that scientific knowledge, skills, and abilities on the one hand, and universal competencies on the other, must be integrated to produce diverse educational outcomes.

According to international assessment research, the sequence for developing students' functional literacy is as follows:

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Reading literacy requires that students comprehend the meaning of a given text, correctly interpret tasks, identify key information, and formulate accurate answers or propose solutions within a short period of time. In the context of chemistry, this involves correctly understanding the question format (open or closed) and identifying key information from the text to arrive at the correct answer using appropriate and simplified chemical formulas.

Currently, there are various forms of test questions used in assessment. Some of these are directly related to our topic. For example, we can illustrate the format of an open test question and explain how students should use the wording in the text to find the correct answer.

Previously, we distinguished between test types as follows: if the answer is selected from given options, it is a closed test; if the answer must be written out, it is an open test**.** Today, test questions are developed based on Bloom's taxonomy (knowledge, comprehension, application, analysis-synthesis, and evaluation), and are used to develop students' functional literacy in preparation for international assessments. When the text includes key terms that guide students to the answer, the question is classified as an open test**.**

Example of an Open Test Question:

"8.55 grams of an alkali metal reacts with hydrochloric acid, producing 1.12 liters of hydrogen gas. Identify the alkali metal used in the reaction."

Solution: This is an open-form, reproductive question. A student who reads the question carefully will quickly recognize the guiding information. Although the alkali metal is unspecified, the volume of hydrogen gas is given, making it possible to determine the metal from stoichiometric relationships.

Let's solve it:

8,55--------------------------1,12

$$2Me + 2HCl \rightarrow 2MeCl + H_2$$

2x----------------------------22,4

$$2x \cdot 1{,}12 = 8{,}55 \cdot 22{,}4$$

$$2{,}24x = 191{,}52$$

$$x = 191{,}52 : 2{,}24$$

$$x = 85{,}5 \ (Me = Rb)$$

Closed Test Question (with Heuristic and INSERT Methods):

"8.55 grams of an alkali metal reacts with an acid, producing 1.12 liters of gas. Identify the metal and the mass of the acid used in the reaction."

Using the INSERT method**,** students are encouraged to carefully analyze the words in the question and understand the underlying problem. This method focuses on deep text comprehension.

The heuristic method is typically used for problem-solving. If a student lacks sufficient reading literacy, they may struggle to formulate guiding questions or arrive at a conclusion. With the heuristic approach, the problem is explored through a series of sub-questions:

1. The metal is given as 8.55 grams — which alkali metal could it be?
2. A gas volume of 1.12 liters is released — which gas is this?

3. The reaction involves an acid — which acid might that be?
4. Was the acid concentrated or diluted in the reaction?

Only by answering these questions can the student solve the closed test task. Thus, it is evident that solving closed test items requires not only reading literacy but also the development of creative thinking skills**.** With these, students can apply prior knowledge and use logical reasoning to find solutions. Mathematical calculations and chemical formulas must often be used to support their answers.

Based on recent analyses — including national certification exams and international assessments — such test designs are increasingly aligned with Bloom's taxonomy.

RESULTS AND RECOMMENDATIONS

Changes in students' knowledge and skills can be illustrated through the following key aspects:

Improvement in Functional Literacy

1. Students are able to apply newly acquired chemical knowledge to solve real-life problems.
2. For example, they can understand chemical processes encountered in daily life and provide scientifically grounded explanations.
3. Students demonstrate improved abilities in independent analysis, planning of experiments, and drawing conclusions based on results.

Development of Logical Thinking

1. Students acquire the ability to analyze cause-and-effect relationships.
2. They understand the interconnections between different types of knowledge while solving complex problems.
3. They can identify chemical laws and apply them in various contexts.

Enhancement of Practical Skills and Laboratory Competence

1. Students show greater accuracy and correctness in writing chemical reaction equations.
2. Their confidence and precision in applying experimental methods have increased.
3. Their skills in interpreting experimental results and providing scientific justification have improved.

Comparison with Traditional Approaches

1. If the application of new methods results in noticeable improvements in students' knowledge and skills, this should be compared to the outcomes of traditional teaching methods.
2. For instance, current academic results should be compared with those of the previous school year to assess effectiveness.

Recommendations

1. To foster functional literacy and logical thinking in chemistry education, it is essential to incorporate advanced pedagogical technologies, interactive teaching methods, and problem-based learning approaches.

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2. Laboratory work, hands-on assignments, and project-based activities should be more broadly implemented in the learning process.
3. Innovative approaches should be developed within the education system, and specialized training programs for teachers must be organized.
4. In order to cultivate independent thinking and analytical reasoning in students, complex task systems should be designed and improvements made to the assessment framework.

CONCLUSION

It is evident that future chemistry teachers with well-developed functional literacies — including creative thinking, reading, mathematical, financial, scientific, and global literacy — will be well-equipped to prepare general secondary school students for participation in international assessment studies.

Key Findings

1.1. Methods aimed at developing functional literacy contribute to enhancing students' ability to solve real-life problems through the application of chemical knowledge.
1.2. The use of logical thinking approaches helps students to cultivate deep analytical reasoning skills.
1.3. Students demonstrated increased interest in the subject of chemistry and showed a greater inclination toward conducting independent scientific research.

Impact on the Educational Process

2.1. The implementation of innovative teaching methods and practical tasks resulted in more effective learning outcomes compared to traditional educational practices.
2.2. Students achieved better outcomes in analyzing experimental results, providing scientific explanations, and integrating theoretical knowledge with practical experience.
2.3. The necessity of using modern technologies and interactive approaches in the teaching of chemistry became even more evident.

REFERENCES

1. I.E.Shernazarov, M.U.Tilyabov, D.E.Avci, A.Yu.Iskandarov, M.F.Yakubova. Kimyo fanini o‘qitishda xalqaro baholash usullaridan foydalanish. Darslik. “IMPRESS MEDIA” MCHJ Toshkent-2025 (376-b).
2. E.Shernazarov, D.E.Avci, A.Yu.Iskandarov, M.U.Tilyabov, M.F.Yakubova. Kimyoda fanlararo integratsiya. Darslik. “DIMAL” MCHJ nashriyoti Toshkent-2024 (199-b)
3. Ismailov A.A., Daminov X.J., Kosimova Z.A., Pirimov G.A. Kreativ fikrlashni baholash// Qo‘llanma. Toshkent. 2021. -B.92
4. M.U.Tilyabov. Funksional savodxonlik kompetensiyalari va ularni o‘quvchilarda shakllantirish usullari. O‘zFinPI Fan va Ta’lim integratsiyasi ilmiy jurnal. 20 dekabr_ 2024_2(4) 222-232 bet

5. M.U.Tilyabov. Functional Literacy Competencies And Methods For Their Development In Future Teachers. International scientific-online conference.Solution of Social Problems in Management and Education System**.** Spain-2025 4(2). 5–8.
6. I.E.Shernazarov, M.U.Tilyabov. Boʻlajak kimyo oʻqituvchilarning funksional savodxonligini rivojlantirish metodikasini takomillashtirish. Mirzo Ulugʻbek nomidagi Oʻzbekiston Milliy universiteti ilmiy jurnali 2024, [1/9]. Issn 2181-7324 184-187 bet.
7. M.U.Tilyabov. Kimyo oʻqituvchilarini PISA tadqiqotiga tayyorlash va funksional savodxonlik asoslari. BuxDU. "Ta'limda istiqbolli izlanishlar" Xalqaro ilmiy metodik jurnali 2025 yil 2-son.

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