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Development of multi-level tasks for the development of natural science literacy of students in chemistry

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Abstract. Most scientists and teachers agree that the development of functional literacy is one of the most important issues in current school education. According to most studies, students have not developed at the appropriate level of reading, mathematical literacy, and natural science literacy. As a result, students in chemistry lessons have trouble solving computational problems, balancing reaction equations according to the proposed scheme, formulating answers to problematic questions, etc. This conflict can be overcome in the classroom by adopting multi-level tasks.

Multi-level tasks need an individual approach, as seen by differences in task content, nature, and volume. The article discusses the present methodological criteria for the content, the most important types and kinds, benefits and drawbacks of multi-level tasks, and the primary aspects of using multi-level tasks in chemistry classrooms. The examples of tasks we have developed are presented on the following topics: "Sulphur. Sulphur compounds" and "Nitrogen. Ammonia" for 9th-grade students in chemistry. Based on the findings, it is possible to conclude that using multi-level tasks in the study of different chemical subjects promotes the success of understanding the educational content because the individual features of each student are taken into consideration.

Keywords: multi-level tasks, problem-solving, functional literacy, natural science literacy, PISA, secondary school, chemistry.

Introduction

Modern education requires new approaches. It sets its standards for the education of children and educational excellence [1]. Today, professionals and academics agree that one of the most pressing issues in school education is the development of functional literacy. In today's quickly changing world, functional literacy is emerging as a critical aspect of people's active engagement in social, cultural, political, and economic activities, as well as lifelong learning [2].

Mathematical literacy, reading literacy, natural science literacy, financial literacy, global awareness, and creative thinking are the key elements of functional literacy. Students may lack sufficient scientific literacy, leading to challenges in solving computational problems, formulating reaction equations following the recommended format, providing responses to complex questions, and so on [3, p.7040].

Science literacy is the ability to use scientific knowledge to identify issues and draw informed conclusions to understand the environment around us and the changes caused by human activities, and to make appropriate decisions. A scientifically literate person seeks to engage in reasoned discussion of scientific and technological issues, which requires the ability to explain phenomena scientifically, understand the main features of scientific research, interpret data, and use scientific evidence to conclude [4, p.136].

Every three years, PISA studies are carried out around the world to assess the scientific literacy of students. These examinations serve as a "litmus paper", highlighting shortcomings in the education systems of many countries around the world. PISA (Programme for International Student Assessment) is an international programme developed by the Organisation for Economic Co-operation and Development (OECD) to measure the educational performance of students [5]. PISA aims to measure the knowledge and skills students need to participate fully in society. In addition to assessing educational achievement, it examines the impact of many factors related to students and their families, school and out-of-school educational opportunities. The study focuses on the educational achievements of 15-year-old children. The choice of these school-age children is explained by the fact that in many countries this is the age at which compulsory schooling ends, and that there are many similarities in the educational programmes of different countries. Natural science literacy is defined by PISA as the ability of students to use natural science knowledge to identify real-world problems that can be investigated and solved using scientific procedures and to draw conclusions based on observations and experiments. These judgements are needed to understand the world around them and the changes that occur in it.

PISA includes three different types of questions:

- multiple-choice questions;
- questions requiring a brief response;
- questions requiring a detailed response.

One possible solution to this problem is to introduce multi-level tasks into the classroom. The various types of differentiated tasks have different levels of complexity, inventiveness and volume. The students themselves decide which one they want to use. The number of tasks in the work is determined by the level of difficulty of the content, the particular qualities of the students and the time available for autonomous work. Preference-based differentiation helps to develop predictive self-esteem. Even before starting the task, the student needs to assess his or her ability to complete it. It is best to gradually complicate the assessment scenario (the teacher does not tell the children which activities are easier or more difficult, and no illustrations are used; the children determine the degree of complexity and their ability) [6, p.5094].

Multi-level tasks are tasks for independent work on the same topic with different levels of complexity, carried out simultaneously by different students. The method of forming scientific literacy is also the allocation of nomenclature of educational tasks common to all science subjects. This nomenclature does not include all forms of educational tasks in each subject, but rather those that are directly aimed at developing the competencies that define scientific literacy.

The core competencies are the following:

• understanding the main features of natural science research (or the natural science method of cognition);

• the ability to explain or describe natural science phenomena based on available scientific knowledge, as well as the ability to predict physicochemical changes;

• the ability to use scientific evidence and available data to conclude, analyse, and evaluate the reliability of these conclusions.

Following these three core competencies, three groups of tasks can be distinguished. Three groups of work can be identified based on these three fundamental abilities. These categories can be grouped under specific headings that are written in a language that students can understand and have a motivational meaning for the learner [7, p.208].

Multi-level tasks are classified into three types:

<u>The first group</u> of activities (reproductive-minimal) corresponds to the first of the skills related to scientific cognition techniques, i.e. methods of acquiring scientific information based on memory. Examples of this type of activity are retelling tasks, conveying definitions that have been taught, completing tasks according to a template, algorithms or tasks that have been discussed repeatedly in class.

<u>The second group</u> of tasks (productive) forms the ability to explain and describe phenomena and predict physicochemical changes or the course of processes.

<u>The third group of tasks (advanced-creative)</u> form the ability to make conclusions from available data. This information can be presented as a series of statistics, figures, graphs, charts, diagrams and verbal descriptions. The study of these data, as well as their structure and generalisation, allows us to draw logical conclusions consisting of the discovery of some patterns, trends, estimations, etc.

Students who are interested in a non-traditional form of activity are more successful in the classroom. A differentiated approach in the classroom allows the teacher to see each student, and each student to see themselves develop and compare themselves throughout the educational process [8].

Different types of multi-level tasks:

<u>1. Individual differentiated-level tasks</u> are designed to assess a student's efficiency, adaptability, concreteness, awareness and strength of knowledge. The number of tasks in the paper is determined by the subject, the level of difficulty and the personal qualities of the student. The recommended time for completion is 10-15 minutes.

2. Differentiated tasks with adaptation involve the student solving his task and discussing it with a classmate and are also used to train and assess the student's ability to complete work according to a model. The tasks of the different levels are designed as follows: the content of the task, the algorithm and how to do the task based on it; and the content of a comparable task for the student to do independently based on the given example. It is best to use these tasks for corrective work with “weak” students and for individual work with students who have missed previous lessons. In addition, each student can, if he/she wishes, develop an algorithm to carry out more complicated tasks in his/her free time.

3. Multi-level test tasks. This type of work is very convenient for both teachers and students because multi-level tests provide sufficient interest in the work and its performance for both weak and strong students, students develop stable skills and knowledge, and a teacher can easily see the whole picture of the mastery of the topic in class. This type of examination should be used as a routine check after a limited amount of material has been studied in the block. Students are asked to complete a series of 10-15 tests, in descending order of complexity, in a given time (17-20 minutes) [9, p.23].

Advantages and disadvantages of using multi-level tasks

Task-based education allows each student to organise their education to maximise their opportunities, especially educational opportunities; it also allows the teacher to focus on working with different types of students.

The benefits of multi-level tasks are:

• a multi-level approach allows the teacher to diagnose the intellectual development of the students;

• taking into account the individual characteristics of the students allows the teacher to set tasks in such a way that the abilities of each student are used;

• effectiveness when used in conjunction with other ways of testing students' knowledge, skills and abilities;

• systematic verification of knowledge.

The drawbacks of multi-level activities are:

• fear of not being able to complete the tasks (insecure students, students with low self-esteem);

• lack of time – students who do not want to risk starting higher level tasks quickly complete the first level tasks, then the second, then the third. As a result, they may not have enough time to complete all the activities [10].

Application of multi-level tasks in chemistry lessons

The chemistry teacher is faced with a difficult challenge; she/he has to improve the student's ability to extract information from academic knowledge. The digestion of information and the search for answers to problems in an unusual way. It is possible to regulate students' mental activity and refresh their acquired information by using multi-level tasks and exercises. Work on tasks that stimulate students' intellectual activity, organise internal memory, develop skills for using external memory, implement a chain of logically related comparisons of information available in the task, and form the ability to link theory with practice. For a chemistry teacher, this task is quite possible, chemistry is a practical science and it is possible to create many tasks with a practical orientation aimed at developing scientific literacy [11, p.475].

The acquisition of theoretical information in chemistry is more thorough and solid throughout the problem-solving process because specific theoretical knowledge becomes an urgent requirement during the problem-solving process. At the same time, the practical importance of chemical knowledge is revealed from many perspectives and the limits of the applicability of chemical theories are established. Solving chemical tasks is an important part of academic activity. Tasks provide material for exercises that require the application of rules to events that occur in particular situations. As a result, they are critical for concretising students' knowledge and for instilling or developing the ability to identify numerous specific examples of universal laws. Without such concretisation, information is only theoretical, without practical relevance.

Problem-solving contributes to a deeper and stronger understanding of chemical laws, to the development of logical thinking, ingenuity, initiative and the determination to persevere to achieve a goal, to an interest in chemistry, to the development of independent working skills and an indispensable tool for the development of judgement. Problem-solving is an approach to understanding the interrelationship of the laws of nature. Chemical tasks should contribute to the disclosure and assimilation of basic chemical concepts, laws, theories, chemical language, deepening and concretisation of knowledge, formation of a materialistic worldview, development of interest in chemistry, development of practical skills, work necessity and environmental education [12].

The goal of our research is to present created and tested multi-level tasks for 9th-grade students based on their natural science abilities.

Methodology

The experiment was carried out on the specialized school «Murager» (Karaganda) in the period from 01.03.2023 to 31.03.2023. Students of the 9th grade took part in the approval of the developed multi-level tasks, there are a total of 24 students (10 girls and 14 boys).

The lessons in Group 1 (control) were given in a traditional style. Traditional teaching involves the passive acquisition of information held by the teacher. The lessons in Group 2 (experimental) were given using multi-level tasks in chemistry. The level of difficulty is used to compile and integrate multi-level tasks: low (level A tasks), medium (level B tasks) and high (level C tasks). They can move on to more difficult tasks as their skills improve.

An achievement tests were used to collect quantitative data. The teacher’s feedback and comments were collected and discussed to monitor the student’s progress. The tests were distributed in paper-and-pencil format. Students had 40 minutes to complete the tests, which consisted of 25 questions (short-answer, long-answer, and multiple-choice). This means that each question took about 1.4 minutes to complete. Topics covered in the tests: «Sulphur and its compounds. Sulphuric acid», and «Nitrogen and its compounds. Ammonia. Nitric acid».

Developed multi-level tasks

1. Sulphur and its compounds. Sulfuric acid.

A – level

Sulphur is found in Periodic Table Group 16. The chemical symbol for sulphur is S. The atomic number of sulphurs is 16, hence the nucleus charge is +16, the number of protons (p^+), the number of neutrons (n^0), and the number of electrons (ē) is 16. Sulphur interacts with numerous elements except for noble gases, I_2, N_2, Pt, and Au.

1. Choose the electronic configuration of a sulphur atom:

A) $1s^22s^22p^63s^23p^1$; B) $1s^22s^22p^63s^23p^63d^54s^1$; C) $1s^22s^22p^63s^23p^6$; D) $1s^22s^22p^6\ 3s^23p^4$; E) $1s^22s^22p^63s^23p^3$.

2. Choose the basic oxidation states of the sulphur:

A) -2; +4; +1; 0; B) 0; +6; +4; -2; C) +3; +2; +7; +5; D) -1; +3; -3; -2; E) -4; +3; +1; -7;

3. Choose the impossible reaction:

A) $S + N_2 \rightarrow$; B) $S + H_2 \rightarrow$; C) $S + Fe \rightarrow$; D) $S + O_2 \rightarrow$; E) $S + Zn \rightarrow$.

4. Choose the option with the correct allotropic forms of sulphur:

A) protium, deuterium, tritium; B) rhombic, monoclinic, plastic; C) diamond, graphite, fullerene; D) red, white, yellow; E) absorbs water, black.

5. Choose the highest hydride formula of the 16 groups: A) RH_2; B) RH_3; C) RH_4; D) RH; E) R_2H_2.

6. Determine the oxidation state of sulphur in compounds: S; SO_2; SO_3; H_2S; H_2SO_3; H_2SO_4; FeS_2; ZnS.

B – level

1. Sulphur in its compounds demonstrates the valences II, IV, VI. Write the electronic configuration of a sulphur atom in oxidation state S^{+6}.

2. Sulphur reacts with oxygen to form valence oxides IV and VI. These are sulphur dioxide and sulphur trioxide (sulphur anhydride). Valence oxides IV and VI are formed when sulphur combines with oxygen. These are sulphur dioxide and sulphur trioxide (sulphur anhydride). SO_2 is a colourless gas, which has a choking smell and is very soluble in water. Sulphur trioxide (SO_3) is a volatile colourless liquid, solid at +17 °C.

Problems:

• Write the structural formula of SO_2 and SO_3.

• Calculate the molar mass of SO_2 and SO_3.

C – level

1. Sulphur dioxide and sulphur trioxide are released into the atmosphere when humans burn fossil fuels and combine with atmospheric water vapour to form acid rain. Acid rain corrodes structures and statues, most of which are made of calcium carbonate. Acid rain damages trees, plants and fish, and also causes respiratory problems in humans and animals (Figure 1).

Figure 1. C-level task: "Sulphur and its compounds. Sulfuric acid"

Problem: Write the reaction of the interaction of calcium carbonate and sulfuric acid.

2. Sulphuric acid (H_2SO_4) is a colourless, odourless, heavy oily liquid that is non-volatile. The contact process is the most commonly used technique to produce sulphuric acid. Sulphur dioxide gas is produced by burning various sulphur-containing minerals such as pyrite (FeS_2). Sulphur dioxide gas (SO_2) is produced by burning sulphur or sulphide compounds in the air. In addition, sulphur dioxide is oxidised to sulphur trioxide (SO_3) by the addition of oxygen gas. Sulphur trioxide is then dissolved in water to produce sulphuric acid. Sulphuric acid is a very strong dibasic acid.

Problem:

- Write the dissociation reaction of sulfuric acid.
- Write the reaction equations that carry out the series of changes $FeS_2 \rightarrow SO_2 \rightarrow SO_3 \rightarrow H_2SO_4$.

2. Nitrogen and its compounds. Ammonia. Nitric acid

A – level

Nitrogen is in Group 15 of the Periodic Table. It is a non-metallic element that makes up about 78% of the Earth's atmosphere. The state of matter is gas. Nitrogen has the chemical symbol – N. The atomic number of nitrogen is 7, so the charge of the nucleus is +7 and the number of protons is (p^+), neutrons (n0), and the number of electrons ($\bar{e}$) is 7.

1. Choose the electronic configuration of a nitrogen atom:

A) $1s^22s^22p^6$; B) $1s^22s^22p^3$; C) $1s^22s^22p^5$; D) $1s^22s^32p^2$; E) $1s^22s^32p^1$.

2. Choose the basic oxidation states of the nitrogen:

A) -2, +4, +1,0; B) 0, +3, -3, +5; C) +3, +2, +7, +5; D) -1, +3, -3, -2; E) +8, +3, +7

3. Choose the option with the correct physical properties of the nitrogen:

A) pale yellow-green gas; B) yellow gas with a suffocating smell; C) brown poisonous gas; D) odourless, colourless gas, lighter than air; E) odourless combustible gas, with colour.

4. How does the oxidation state change in the chain? $NH_3 \rightarrow NO \rightarrow N_2$:

A) increases; B) first decreases, then increases; C) decreases; D) first increases, then decreases; E) no change occurs.

5. Choose the highest oxide formula of the nitrogen group: A) R_2O; B) RO_2; C) R_2O_5; D) R_2O_3; E) R_2O_8

6. Determine oxidation state of nitrogen in compounds: N_2, NH_3, NO, NO_2, N_2O, N_2O_3, N_2O_5, Li_3N.

B – level

1. Nitrogen forms five different oxides. Oxides with valences II and IV play a very important role in nature. During thunderstorms, nitrogen (II) oxide is produced in the air. The nitrogen (II) oxide produced is further oxidised by oxygen in the air to form nitrogen (IV) oxide.

Problem: Write the structural formula of nitrogen (II) monoxide and nitrogen (IV) dioxide.

2. Ammonia is a particularly important nitrogen molecule. It's an alkaline gas with the formula NH3. It is a gas that is lighter than air, very soluble in water and has a strong odour. Ammonia is produced industrially by mixing nitrogen and hydrogen.

Problems:

- Write the structural formula of ammonia.
- Write the reaction for obtaining ammonia industrially.

C – level

1. Factories also emit large amounts of nitrogen oxides, which react with atmospheric water vapour to form acid rain. There are two types of acid: nitrous acid and nitric acid. Metals, coatings on metal surfaces and synthetic materials are all corroded by acid rain. In Karaganda cities, acid rain attacks buildings and statues, especially those made of carbonate rock. The most common of these is limestone, which contains calcium carbonate. Acid rain also damages forests (Figure 2).

Figure 2. C-level task: "Nitrogen and its compounds. Ammonia. Nitric acid"

Problems:
- Write the reaction of the formation of nitrogen (IV) oxide.
- Write the reaction of the interaction of calcium carbonate and nitric acid.

2. Nitric acid (HNO3). This colourless liquid has a strong odour and corrosive characteristics. Water solubility is excellent. In the laboratory, sodium nitrate is dissolved in strong sulfuric acid.

Problems:
- Describe the laboratory reaction for obtaining nitric acid.
- Write the nitric acid dissociation process.
- What are nitric acid salts called?

Discussion and Results

Diagrams 1-4 show the average score and grades for the tests in group 1(control group) and group 2 (experimental group).

Sulphur and its compounds. Sulfuric acid

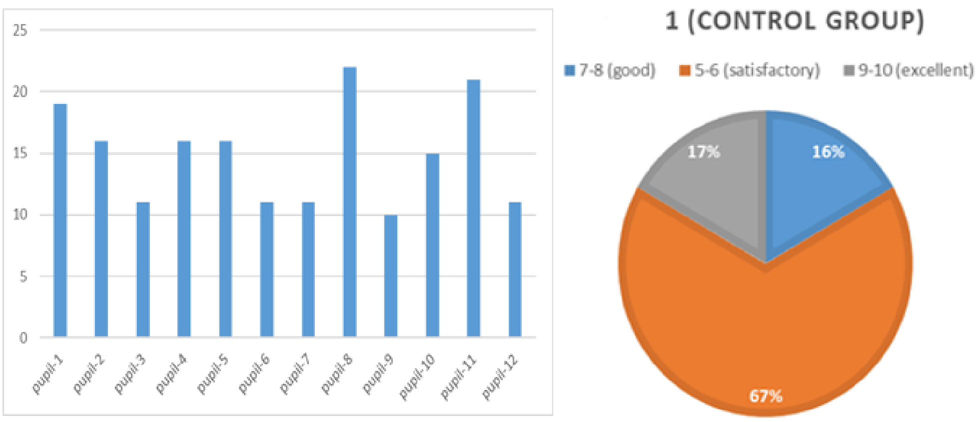

Diagram 1. Results of testing "Sulphur and its compounds. Sulphuric acid" in control groups

8 students – satisfactory (67%);
2 students – good (17%);
2 students – excellent (16%).

Based on the final testing data, the quality of knowledge was 33%. The average score was 14.92 points.

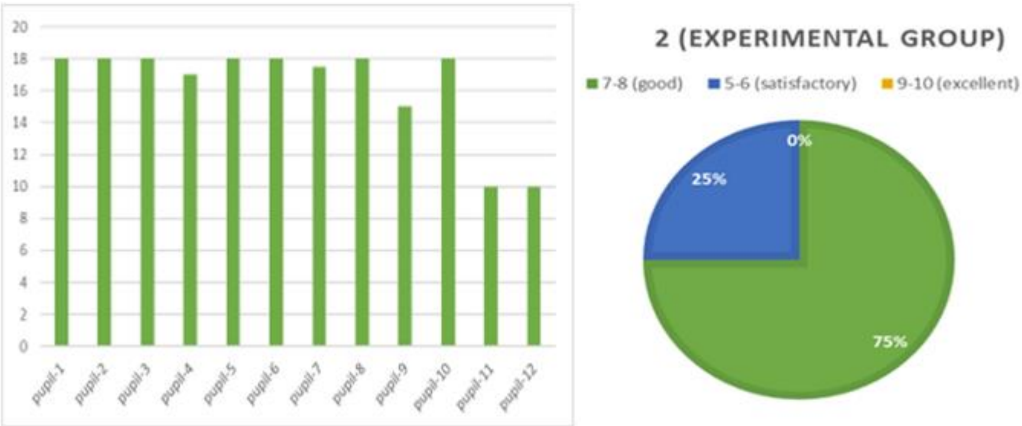

Diagram 2. Results of testing "Sulphur and its compounds. Sulphuric acid" in experimental groups

3 students – satisfactory (25%);
9 students – good (75%).

Based on the final testing data, the quality of knowledge was 75%. The average score was 16.3 points. There was only a slight difference in the degree of knowledge on the topic of «Sulphur and its compounds. Sulfuric acid» between the two groups: 1- control and 2- experimental. The experimental group scored 1.38 more points than the control group.

Nitrogen and its compounds. Ammonia. Nitric acid

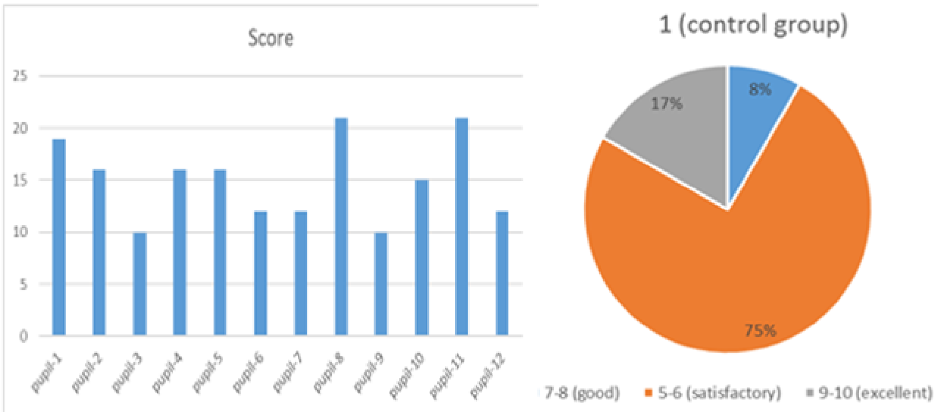

Diagram 3. Results of testing "Nitrogen and its compounds. Ammonia. Nitric acid" in control groups

9 students – satisfactory (75%);
1 student – good (8%);
2 students – excellent (17%).

Based on the final testing data, the quality of knowledge was 25%. The average score was 15 points.

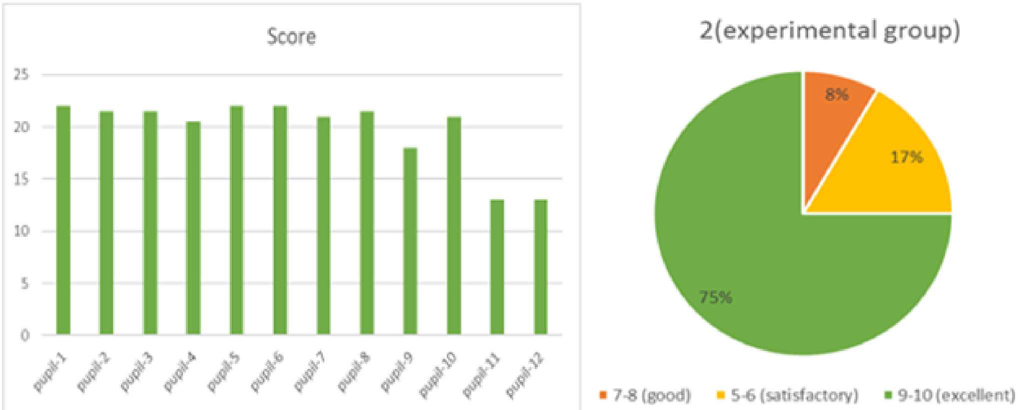

Diagram 4. Results of testing "Nitrogen and its compounds. Ammonia. Nitric acid" in experimental groups

2 students – satisfactory (17%);
1 student – good (8%);
9 students – excellent (75%).

Based on the data of the final testing, the quality of knowledge was 83%. The average score was 19.75 points.

There was only a major difference in the degree of knowledge on the topic of « Nitrogen and its compounds. Ammonia. Nitric acid» between the two groups: control and experimental groups. The experimental group scored 4.75 more points than the control group.

The use of multi-level tasks in the classroom allows all students to be involved in the learning process, to feel involved in discovery and to enjoy the learning process. Students are offered tasks at different levels and they determine the level of the tasks themselves. This contributes to the motivation of students who want to solve advanced tasks. However, in a mass school, it is difficult for teachers to develop tasks of three levels that meet the requirements for tasks, so differentiation is usually carried out more simply.

Qiao et al. [13, p.14], Suarez-Mesa and Gomez [14], Irwanto et al. [15, p.312] highlight the difficulties and possible solutions to these issues:

1. Students' scepticism. It is suggested to have a dialogue with an individual student as well as with a class. To avoid offending anyone, the teacher should explain the differences between the tasks. The teacher can offer a second-level task to an insecure student, motivate them and create a successful environment. Examine the tasks in the textbook and determine their level (display the level number in the lesson). Examine supplementary literature, task collections, online publications and task collections of different levels on topics.

2. Not enough time to complete all the tasks. It is advisable to design the activities as tasks with an attractive design (e.g. in a frame) that indicates the level of complexity. Organise such problems by topic, create answers (keys) and use them frequently. These tasks can be exchanged with other teachers and shared on the Internet. It should be noted that to obtain more reliable data on the impact of multi-level tasks on the learning process, more in-depth research is needed for further development and improvement of the educational system.

As a recommendation, using our example, we suggest that current teachers master various types of tasks for conducting such lessons and, if possible, use them as much as possible in the process of implementing their professional activity to achieve high results, stimulate the growth and development of competitive youth.

Conclusion

The teacher should always keep in mind that the development of functional literacy is a varied, time-consuming and complex process. Good results can be achieved when a teacher skillfully combines sophisticated teaching techniques and procedures in their role. Students acquire the analytical ability to assimilate knowledge, independent creative work, and also a condition for self-realisation, which is an indispensable requirement for the modernisation of Kazakh education.

The educational experiment was carried out with 9th-grade students. The class was divided into two groups: experimental and control. The results of the control group on the first topic: “Sulphur and its compounds” through multi-level tasks showed the quality of education to be 50% and the experimental group to be 75%. The results of the control group on the second topic: “Nitrogen and its compounds” over different levels of tasks showed a quality of education of 50%, that is, no change, and the experimental group was 83%. Calculating the percentages, we can say that the quality of knowledge of the experimental group increased by 8%. Based on the results, it can be concluded that multi-level learning tasks are suitable for regular use in school chemistry teaching, especially for students with lower grades. Thus, solving multi-level learning tasks consolidates students' knowledge, develops their skills and abilities and contributes to the development of educational disciplines and scientific literacy.

Through personal choice, the proposed strategy helps students to create a “situation of independent choice” for themselves in class. Furthermore, it allows not only to identification of specific information and skills on the topic but also to assess their assimilation in a complex, predict learning consequences, creates an opportunity for the creative application of knowledge and serves as a motivation for further growth and self-improvement. As a means of ongoing control, multi-stage tasks allow you to objectively and thoroughly analyse the students' mastery of the relevant topic of the previous lesson, each pedagogical question and the topic of the lesson. Multi-stage tasks can be successfully used when learning new information, monitoring the acquisition of knowledge and skills, and testing knowledge and skills.

Acknowledgements, conflict of interest

No conflict of interest.

Contribution of the authors

In writing the article “Development of multi-level tasks for the development of natural science literacy of students in chemistry”, the authors' contribution is equally distributed and shared among them:

Sadykov Timur Meiramovich – significant contribution to the conception or design of the work; analysis or interpretation of the results of the work.

Kokibasova Gulmira Tolepbergenovna – drafting and/or critical revision of the text, approval of the final version of the article.

Nurmysh Sayan Dauytkhanovich – research, analysis or interpretation of the results of the work.

References

1. Sadykov T., Ctrnactova, H. Application interactive methods and technologies of teaching chemistry // Chemistry Teacher International. – 2019. – Vol. 1 (2). Electronic resource] – URL: https://doi.org/10.1515/cti-2018-0031 (accessed:16.05.2024).

2. Sadykov T., Kokibasova G., Minayeva Y., Ospanova A. Kasymova M. A systematic review of programmed learning approach in science education //Cogent Education. – 2023. – Vol. 10 (1). [Electronic resource] – URL: https://doi.org/10.1080/2331186X.2023.2189889 (accessed:16.05.2024).

3. Cahyana U., Paristiowati M., Savitri D.A., Hasyrin, S.N. Developing and Application of Mobile Game Based Learning (M-GBL) for High School Students Performance in Chemistry //Eurasia Journal of Mathematics, Science and Technology Education. – 2017. – Vol.13 (10). – P.7037–7047. DOI: https://doi.org/10.12973/ejmste/78728.

4. Tamassia L., Frans, R. Does integrated science education improve scientific literacy? // Journal of the European Teacher Education Network, – 2014. –Vol. 9. – P. 131-141.

5. OECD. Students, computers and learning. Making the connection. PISA: OECD Publishing. [Electronic resource] – URL:https://www.oecd.org/ education/education-at-a-glance-2015.htm (accessed:16.04.2023)

6. Udompong L., Wongwanich, S. Diagnosis of the Scientific Literacy Characteristicsa of Primary Students //Social and Behavioral Sciences. – 2014. – Vol.116. – P. 5091-5096.

7. Núñez I.B., do Amaral E.M.R, de Faria Oliveira M.V., Pereira L.F. Activity theory proposed by A.N. Leontiev applied to signify and to structure problem-solving experimental activity in chemistry teaching // Lomonosov Psychology Journal. – 2021. Vol.4. – P.192–233. DOI: https://doi.org/10.11621/vsp.2021.04.06.

8. Токарева Е.А. Разноуровневые задания на уроках как средство развития познавательной активности младших школьников: сборник разноуровневых заданий. [Electronic resource] – URL: http://www.rusnauka. com/40_ PRNT_2016/Pedagogica/5_218044.doc.html (дата обращения:16.04.2024).

9. Khurramov R. Educational tasks in the primary class are a tool for developing student’s heuristic skills // World Bulletin of Social Sciences. – 2022. – Vol.13. – P. 22-25.

10. Hwang G.J., Zou D., Lin J. Effects of a multi-level concept mapping-based question-posing approach on students’ ubiquitous learning performance and perceptions // Computers & Education.

– 2020. – Vol.149 (C) [Electronic resource] – URL: https://doi.org/10.1016/j.compedu.2020.103815 (accessed:5.08.2024).

11. Distler P., Teply P. Scientific literacy in the curriculum of the Czech Republic and its development in chemistry classes // Turkish Online Journal of Educational Technology. – 2016. – Vol.12 (special issue). – P.473-477.

12. Естественно-научная грамотность учащихся: учебное пособие. Филиал «Центр педагогических измерений. АОО «Назарбаев Интеллектуальные школы». [Электрон.ресурс.] – URL: https://bit.ly/3A33Dwt (дата обращения:16.04.2024).

13. Qiao C., Chen Y., Guo Q. Understanding science data literacy: a conceptual framework and assessment tool for college students majoring in STE // International Journal of STEM Education. – 2024. – Vol. 11. – P. 1-25. DOI: https://doi.org/10.1186/ s40594-024-00484-5.

14. Suárez-Mesa, A.M., Gómez, R.L. Does teachers' motivation have an impact on students' scientific literacy and motivation? An empirical study in Colombia with data from PISA 2015 // Large-scale Assessments in Education. – 2024. – Vol. 1 [Electronic resource] – URL: https://doi.org/10.1186/ s40536-023-00190-8 (accessed:16.04.2024).

15. Irwanto I, Suryani E., Zahraini Z.N. The Influence of Process-Oriented Guided Inquiry Learning on Eleventh Grade Students' Chemical Literacy // International Journal of Religion. – 2024. – Vol. 6 (5). – P. 308-316. DOI: https://doi.org/10.61707/we15rd19.

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Разработка разноуровневых заданий для развития естественно-научной грамотности учащихся по химии

Аннотация. Большинство ученых и педагогов считают, что формирование функциональной грамотности является одной из актуальных проблем современного школьного образования. Как показывает большинство исследований, у школьников не сформированы на должном уровне читательская, математическая грамотность и естественно-научная грамотность, и, как следствие, обучаемые на уроках химии затрудняются при решении расчётных задач, составлении уравнений реакций по предложенной схеме, формулировании ответов на проблемные вопросы и т.д. Разрешить данное противоречие можно при использовании на уроках разноуровневых заданий.

Разноуровневые задания подразумевают индивидуальный подход, который проявляется в различии заданий по содержанию, характеру, объему.

В статье описаны современные методические требования к содержанию, основные виды и типы, преимущества и недостатки разноуровневых заданий, а также основные особенности по применению разноуровневых задач на уроках химии. Представлен пример разработанных заданий по темам: «Сера. Соединения серы», «Азот. Аммиак» для учащихся 9-х классов по химии. На основании полученных результатов можно сделать вывод о том, что применение разноуровневых заданий при изучении отдельных тем химии повышает успешность усвоения учебного материала, так как при этом учитываются индивидуальные особенности каждого ученика.

Ключевые слова: разноуровневые задачи, решение задач, функциональная грамотность, естественно-научная грамотность, PISA, средняя школа, химия.

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Химия пәнінен оқушылардың жаратылыстану сауаттылығын дамытуға арналған көп деңгейлі тапсырмаларды құрастыру

Аңдатпа. Көптеген ғалымдар мен педагогтер функционалдық сауаттылықты қалыптастыру қазіргі мектептегі білім берудің өзекті мәселелерінің бірі деп есептейді. Көптеген зерттеулер көрсеткендей, мектеп оқушыларының оқу сауаттылығы, математикалық және жаратылыстану сауатылылығы тиісті деңгейде қалыптаспаған, соның салдарынан оқушылар химия сабағында есептер шығаруда, берліген схемамен реакция теңдеулерін жазуда, проблемалық сұрақтарға жауаптар тұжырымдауда және т.б. қиналады. Сабақтарда көп деңгейлі тапсырмаларды қолдана отырып бұл қарама-қайшылықты шешуге болады.

Көп деңгейлі тапсырмалар мазмұны, сипаты, көлемі бойынша тапсырмалар айырмашылығы көрінетін жекедара тәсілді білдіреді.

Мақалада көп деңгейлі тапсырмалардың мазмұнына қойылатын заманауи әдістемелік талаптар, негізгі түрлері, олардың артықшылықтары мен кемшіліктері, сондай-ақ химия сабақтарында көпдеңгейлі тапсырмаларды қолданудың негізгі ерекшеліктері сипатталған. 9 сынып оқушыларына арнап «Күкірт. Күкірттің қосылыстары», «Азот. Амииак» тақырыптары бойынша құрастырылған тапсырмалар көрсетілген. Алынған нәтижелерге сүйене отырып, химиядағы жеке тақырыптарды зерттеу кезінде көп деңгейлі тапсырмаларды қолдану оқу материалын игерудің сәттілігін арттырады деген қорытынды жасауға болады, өйткені бұл әр оқушының жеке дара ерекшеліктерін ескереді.

Түйін сөздер: көп деңейлі тапсырмалар, есептер шығару, функционалды сауаттылық, жаратылыстану сауатттылығы, PISA, орта мектеп, химия.

References

1. Sadykov T., Ctrnactova H. Application interactive methods and technologies of teaching chemistry, Chemistry Teacher International, 1(2), (2019). [Electronic resource] – Available at: https://doi.org/10.1515/cti-2018-0031 (accessed:16.04.2024)

2. Sadykov T., Kokibasova G., Minayeva Y., Ospanova A., Kasymova M.A systematic review of programmed learning approach in science education, Cogent Education. 10(1), (2023). [Electronic resource] – Available at: https://doi.org/10.1080/2331186X. 2023.2189889 (accessed:16.05.2024).

3. Cahyana U., Paristiowati M., Savitri D.A., Hasyrin, S.N. Developing and Application of Mobile Game Based Learning (M-GBL) for High School Students Performance in Chemistry, Eurasia Journal of Mathematics, Science and Technology Education, 13 (10), 7037–7047 (2017). DOI: https://doi.org/10.12973/ejmste/ 78728.

4. Tamassia L., Frans, R. Does integrated science education improve scientific literacy, Journal of the European Teacher Education Network, 9, 131–141 (2014).

5. OECD. Students, computers and learning. Making the connection. PISA: OECD Publishing. [Electronic resource] – Available at: https://www.oecd.org/ education/education-at-a-glance-2015.htm (accessed:16.04.2024)

6. Udompong L., Wongwanich, S. Diagnosis of the Scientific Literacy Characteristicsa of Primary Students, Social and Behavioral Sciences, 116. 5091–5096 (2014).

7. Núñez I.B., do Amaral E.M.R, de Faria Oliveira M.V., Pereira L.F. Activity theory proposed by A.N. Leontiev applied to signify and to structure problem-solving experimental activity in chemistry teaching. Lomonosov Psychology Journal, 4, 192–233 (2021). DOI: https://doi.org/10.11621/vsp.2021.04.06.

8. Tokareva E.A. Raznourovnevye zadaniya na urokah kak sredstvo razvitiya poznavatel'noj aktivnosti mladshih shkol'nikov: sbornik raznourovnevyh zadanij [Multi-level tasks in the classroom as a means of developing cognitive activity of younger schoolchildren: a collection of multi-level tasks]. [Electronic resource]. –Available at: http://www.rusnauka. com/40_ PRNT_2016/Pedagogica/5_ 218044.doc.html (accessed:16.04.2024) [in Russian].

9. Khurramov R. Educational tasks in the primary class are a tool for developing student’s heuristic skills, World Bulletin of Social Sciences, 13, 22– 25 (2022).

10. Hwang G.J., Zou D., Lin J. Effects of a multi-level concept mapping-based question-posing approach on students’ ubiquitous learning performance and perceptions. Computers & Education. [Electronic resource] – Available at: https://doi.org/10.1016/j.compedu.2020.103815 (accessed:5.08.2024).

11. Distler P., Teply P. Scientific literacy in the curriculum of the Czech Republic and its development in chemistry classes, Turkish Online Journal of Educational Technology, 12 (special issue), 473-477 (2016).

12. Estestvennonauchnaya gramotnost' uchashchihsya: Uchebnoe posobie Filial «Centr pedagogicheskih izmerenij» [Natural science literacy of students: Textbook Branch “Center of pedagogical measurements”]. AOO «Nazarbaev Intellektual'nye shkoly» [Nazarbayev Intellectual schools]. [Electronic resource]. Available at: https://bit.ly/3A33Dwt (accessed:16.04.2024) [in Russian].

13. Qiao C., Chen Y., Guo Q. Understanding science data literacy: a conceptual framework and assessment tool for college students majoring in STE, International Journal of STEM Education, 11, 1-25 (2024). DOI:https://doi.org/10.1186/ s40594-024-00484-5.

14. Suárez-Mesa, A.M., Gómez, R.L. Does teachers’ motivation have an impact on students’ scientific literacy and motivation? An empirical study in Colombia with data from PISA 2015 // Large-scale Assessments in Education. [Electronic resource] –Available at: https://doi.org/10.1186/s40536-023-00190-8 (accessed:16.04.2024).

15. Irwanto I, Suryani E., Zahraini Z.N. The Influence of Process-Oriented Guided Inquiry Learning on Eleventh Grade Students’ Chemical Literacy, International Journal of Religion, 6(5), 308-316 (2024). DOI: https://doi.org/ 10.61707/we15rd19.

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