

S.B. Abeuova¹, D.D. Naushabekova¹, D.M. Muslimova¹,
E.B. Abeuova², E.K. Tussupbekova³, A.T. Dyussekeyeva¹

¹*Ye.A. Buketov Karaganda State University, Kazakhstan;*

²*102 school-gymnasium, Karaganda, Kazakhstan;*

³*Karaganda State Technical University, Kazakhstan*

(E-mail: abeuova.salta@gmail.com)

Application of technology of problem-based learning in the discipline «Methodology of carrying out school chemical experiment»

The article presents the results of an experiment on the application of problem-based learning technology in teaching chemistry. Problem learning is aimed at the independent search for new knowledge and ways of action, and also involves a consistent and purposeful promotion of cognitive problems, through the resolution of which students actively learn new knowledge. Technology of problem-based learning was used in the discipline «Methodology of carrying out of school chemical experiment» with the students of the third course. Two demonstration experiences in chemistry were chosen as problem situations in our case. Updating of knowledge was carried out before the experiment. Then there was the creation of a problem situation and the formulation of the problem. The chemical experiment was shown by a teacher. The situations were considered by students. Then conclusions were drawn. The questionnaire of A.A. Rean and V.A. Yakunin was used for diagnostics of educational motivation of students. Knowledge of problem situations was tested with the test method before and after the experiment. To identify opinions of students on the technology of problem-based learning the individual interviews were conducted. As a result of application of technology of problem-based learning cognitive and research interest, search features and abilities were created, opportunities for cooperation of the teacher with students were opened that promoted deeper and strong assimilation of material. Despite the disadvantages of problem learning, including high time costs, the presence of the necessary «starting» level of knowledge of students, today the idea of problem learning has been successfully implemented in the systems of developmental education.

Keywords: problem-based learning, problem situations, new technologies of teaching chemistry, chemical experiment, methods of teaching chemistry.

Introduction

Currently, problem learning is widely used in many disciplines, as one of the techniques of modern learning technologies [1–3]. It involves the creation of teacher-led problem situations and active independent activity of students to resolve them. This type of training is aimed at independent search of students for new concepts and methods of action. The main purpose of the technology of problem learning is the development of thinking and abilities of students, the assimilation of their knowledge and skills obtained in the active search and independent problem solving. As a result, such knowledge is stronger than traditional training. In the learning process, students are put forward cognitive problems, the resolution of which (under guidance of a teacher) leads to the active assimilation of new knowledge. Problem learning provides a special way of thinking, strength of knowledge and their creative application in practice.

It is possible to create problem situations and solve them with the help of various methods, with the involvement of visual and technical means of training, as well as with the application of chemical experiment [4, 5]. For example, in the production of demonstration and laboratory experiments, the results of which students cannot explain using their knowledge, because these results usually contain new information, which requires new knowledge to understand. Such experiments are carried out before the study of a new topic or a separate issue, as well as before the generalization of all the material. First, students simply observe the phenomena, and then, when a problem arises, consider their essence deeply and comprehensively. Demonstration and laboratory experiments in the process of problem training can serve as a material for creating problem situations, and used to solve them.

Chemical experiment is a source of knowledge, promotion and testing of hypotheses, a means of securing knowledge and control. Through laboratory and demonstration experiments, the teacher creates certain organizational conditions for the activation of mental activity of students, stimulating the search for missing knowledge to resolve cognitive contradictions.

Experimental

Pedagogical experiment was conducted in the classes on the discipline «Methodology of carrying out of school chemical experiment» among third-year students. The experiment involved 8 students (female), who are trained in the specialty «chemistry-education» and are future teachers. They can apply the acquired knowledge in their future professional activity. During the class, students worked in groups.

Diagnostics of educational motivation of the respondents (before and after experiment) was carried out according to the method of A.A. Rean and V.A. Yakunin [6].

Knowledge of students about problem situations was evaluated by testing. The test consisted of 30 questions on the following topics, namely properties of nonmetal oxides, bases, acids, salts; electrolytic dissociation; monobasic carboxylic acids; double bond; chemical properties of ethylene. Testing was conducted twice, namely before the experiment (pre-test) and after the experiment (post-test).

We conducted an individual interview after the experiment in order to identify the views of students about the problem-based learning.

Two demonstration experiences were selected to create a problem situation. Depending on the level of training of students problem situations are analyzed by students under the guidance of a teacher or independently. Then students find ways to solve the problem and draw conclusions.

Demonstration experiment No. 1

Preparation of carbon dioxide and testing its properties

Purpose: Show the dependence of the properties of carbon dioxide on its composition and structure.

Reagents and equipment: Pieces of marble or limestone, solutions of hydrochloric acid and universal indicator, lime or barite water, highly diluted sodium hydroxide solution; gas discharge tube for carbon dioxide, laboratory tripod, test tubes.

Updating of existing knowledge: Students know the general properties of non-metal oxides. They also understand the properties of bases, acids and salts from the point of view of the theory of electrolytic dissociation. During the introductory conversation, they restore the properties of these substances in memory.

The creation of problem situation and statement of the problem: The composition of carbon dioxide refers to non-metal oxides. Considering the electronic formula of carbon dioxide, the saturation of carbon bonds with oxygen and their strength (covalent nonpolar bonds) are noted. Hence, carbon dioxide is a compound in which there was a complete oxidation of the carbon atom. This gives you the opportunity to claim that the carbon dioxide is able to demonstrate general properties of non-metals oxides. The problem is to test experimentally whether carbon dioxide will interact with water and alkalis.

The nomination of hypothesis: Students assume that carbon dioxide exhibits chemical properties similar to the general properties of non-metal oxides.

The solution to the problem and conclusions: The experiments were demonstrated by a teacher, or they were performed by students.

1. Pieces of marble or limestone are lowered into the carbon dioxide device and a solution of hydrochloric acid (1:4) is added. There is a release of gas bubbles-carbon dioxide.

2. Carbon dioxide is passed into the test tube with water colored with a solution of the universal indicator. There is a change in the color of the indicator.

3. Carbon dioxide is passed firstly in a test tube with lime water, and then in a test tube with a highly diluted solution of sodium hydroxide, which wetted with a universal indicator. In the first test tube there is turbidity of the solution, in the second is discoloration.

Students explain the nature of the observed experiments, make the reaction equations and come to the conclusion that carbon dioxide exhibits the general properties of nonmetal oxides and get it as well as most gaseous oxides.

Demonstration experiment No. 2

The ratio of oleic acid to bromine water and potassium permanganate solution

Purpose: To show the dependence of unsaturated properties of oleic acid on its composition and structure.

Reagents and equipment: Oleic acid, bromine water, potassium permanganate solution, test tubes.

Updating of existing knowledge: Students revise in memory the structure of the double bond, its characteristics and chemical properties of ethylene and its homologues. They also recall the chemical properties of monobasic carboxylic acids.

The creation of problem situation and statement of the problem: According to the molecular formula of oleic acid $C_{18}H_{34}O_2$ students make its structural formula and determine the structure, note the presence in the oleic acid molecule of one double bond and one functional carboxyl group. Students characterize this acid as a substance exhibiting the properties of carboxylic acids and unsaturated compounds. They suggest the properties of oleic acid due to double bond. The problem is posed: to test experimentally the possibility of interaction of oleic acid with bromine water and potassium permanganate solution.

The nomination of hypothesis: Students assume that oleic acid exhibits properties similar to ethylene due to the presence of a double bond in molecule of the oleic acid.

The solution to the problem and conclusions: The experiments were demonstrated by a teacher, or they were performed by students.

1. 2 cm^3 of oleic acid and bromine water is poured into a test tube. The tube is closed with a stopper and is shaken. There is discoloration of bromine water.

2. 2 cm^3 of oleic acid and potassium permanganate solution is poured into a test tube. The tube is closed with a stopper and also is shaken. There is discoloration of potassium permanganate solution.

Students write the reaction equations, explain the essence of the experiments and come to the conclusion that oleic acid along with the properties of carboxylic acids also shows the properties of unsaturated compounds, which indicates its dual nature.

Results and Discussion

Questionnaire consisted of 34 questions [6]. Students evaluated on a 5-point system given the motives of educational activity on the importance for them: 1 point corresponds to the minimum significance of the motive, 5 points — the maximum.

Scale 1. Communicative motives — 7, 10, 14, 32 questions;

Scale 2. Avoiding Motives — 6, 12, 13, 15, 19 questions;

Scale 3. Prestige motives — 8, 9, 29, 30, 34 questions;

Scale 4. Professional motives — 1, 2, 3, 4, 5, 26 questions;

Scale 5. Motives of creative self-realization — 27, 28 questions;

Scale 6. Educational and cognitive motives — 17, 18, 20, 21, 22, 23, 24 questions;

Scale 7. Social motives — 11, 16, 25, 31, 33 questions.

When processing the test results, the average for each scale of the questionnaire was calculated.

Diagnostics of educational motivation of students according the questionnaire of A.A. Rean and V.A. Yakunin showed the increase of communicative, professional, educational and cognitive motives (Table 1).

The results of students on the scales of motives of avoiding and prestige remained unchanged. This shows that before and after the study, the desire of students to keep up with fellow students, to be among the best students and to get approval from parents and others remains at the same level (not changed).

Table 1

Diagnostics of educational motivation of students (before and after the experiment)

No.	Scales of motives	Values of respondents (before and after experiment)															
		1		2		3		4		5		6		7		8	
		Be- fore	After	Be- fore	After	Be- fore	After	Be- fore	After	Be- fore	After	Be- fore	After	Be- fore	After	Be- fore	After
1	Communicative motives	3.5	4.5	3.8	4.5	4	4.3	3.8	4.3	3.3	4	3.8	4.3	3	4	3.8	4.8
2	Avoiding Motives	3	3	3.2	3.2	3	3	3	3	2.8	2.8	3.2	3.2	2.8	2.8	2.8	2.8
3	Prestige motives	4	4	4.6	4.6	4.4	4.4	3.8	3.8	4	4	4.4	4.4	3.2	3.2	3.8	3.8
4	Professional motives	5	5	5	5	5	5	4.3	5	5	5	4.2	4.7	3.5	4.7	4.5	5
5	Motives of creative self-realization	4	4	4	4	4	4	4.5	4.5	4	4	3.5	3.5	3	3	3	3
6	Educational and cognitive motives	4	4.6	4.1	4.7	4.1	4.6	3.9	4.7	3.9	4.6	3.4	4.7	3.3	4.4	3.4	4.6
7	Social motives	4.4	4.4	4.6	4.6	4.2	4.2	4	4	3.8	3.8	3.8	3.8	3.8	2.8	3.2	3.2

Testing for knowledge of problem situations showed that the number of students with good results increased (Table 2, Fig.).

Table 2

Testing results for knowledge of problem situations

Number of correct answers	Number of students	
	Before experiment	After experiment
High index (23–30)	2	4
Average index (15–22)	4	3
Low index (1–14)	2	1

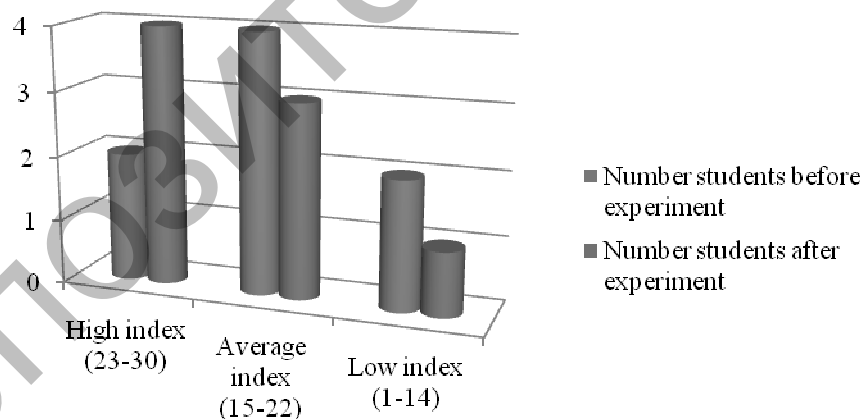


Figure. Analysis of the test for knowledge of problem situations (before and after experiment)

Table 3 presents data from the analysis of interviews on the applicability of problem-based learning at chemistry lessons. The results show the answers that students most often indicated in the interview. The analysis showed that problem-based learning has a great impact on learning skills, life and cognitive skills.

Despite the advantages, problem learning also has disadvantages among which «weak interaction between some students» and «Treating the passive group members equally with the others».

Table 3

Analysis of student interviews about the applicability of PBL

Category	Answers of students	Number of students
Learning skills	PBL encouraged us to do individual investigations	7
	I challenged my phobia of public speaking	4
	We built intragroup and intergroup communication skills and to make presentations	6
Life skills	There was a good communication in our group	5
	Acquired knowledge helped to improve more communication skills	7
	PBL helped students to improve their self-confidence	6
	Group works contributed to the interaction and increased our motivation to learn chemistry	6
	Presentations increased our self-confidence and self-expression	5
	PBL was related to effective use of time	5
Cognitive skills	Problem scenarios were interesting. Therefore, working on it was also interesting	7
	The scenarios had a positive effect on the our curiosity	6
Shortcomings	Weak interactions between some students	2
	Treating the passive group members equally with the others	2

Conclusions

The use of problem-based learning technology in chemistry teaching increases interest of students in the search for new knowledge, provides a special type of thinking, the strength of knowledge acquisition and their creative application in practice. As a result, the students formed the motivation to succeed, develop mental abilities. Diagnostics of educational motivation showed that students increased cognitive and research interest, search features and skills. They became more open to creative cooperation. Testing for knowledge of problem situations showed an increase in the level of knowledge.

However, the technology of problem-based learning, like other technologies, has positive and negative sides. Interviews revealed advantages and disadvantages of the application of problem-based learning. Along with increasing communication skills and research interest, there is a weak control of cognitive activity of students. The technology of problem-based learning requires a lot of time to prepare for the lesson, the necessary starting level of students, and the creative approach of the teacher. Despite the identified shortcomings, nowadays, problem-based learning is the most promising, compared with traditional methods of training, and can be successfully used in teaching chemistry.

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С.Б. Абеуова, Д.Д. Наушабекова, Д.М. Муслимова,
Э.Б. Абеуова, Э.К. Тусупбекова, А.Т. Дюсекеева

Проблемалық оқыту технологиясын «Мектепте химиялық экспериментті жүргізу әдістемесі» пәні сабақтарында қолдану

Мақалада химия сабақтарында проблемалық оқыту технологиясын қолдану бойынша эксперимент нәтижелері келтірілген. Проблемалық оқыту жаңа білім мен іс-қимыл тәсілдерін өз бетімен іздестіруге бағытталған оқыту болып табылады, сондай-ақ мұғалімнің жетекшілігімен жаңа білімдерді белсенді түрде игеріп жатқан студенттерге когнитивті проблемаларды дәйекті және мақсатты түрде алға қоюларын көздейді. Проблемалық оқыту технологиясы үшінші курс студенттеріне «Мектепте химиялық экспериментті жүргізу әдістемесі» пәнін жүргізу барысында қолданылды. Химиядан проблемалық жағдай ретінде екі көрнекілік тәжірибе таңдалды. Тәжірибе алдында білім өзектендірілді. Содан кейін проблемалық жағдайды жасау және мәселені тұжырымдау қажет. Мұғалім химиялық тәжірибені көрсетеді. Студенттер жағдайды саралап, қорытынды жасайды. Студенттердің оқуға деген ынтасын тексеру мақсатында А.А. Реан және В.А. Якунин сауалнамасы қолданылды, проблемалық жағдайларды анықтай білуі тест әдісі арқылы тәжірибе алдында және тәжірибеден кейін алынып, бағаланды. Студенттердің проблемалық оқыту технологиясы бойынша пікірлерін анықтау үшін жеке сұхбат жүргізілді. Проблемалық оқыту технологияларын қолдану нәтижесінде студенттердің когнитивтік және зерттеу қызығушылықтары пайда болды, іздеу ерекшеліктері мен дағдылары артты, сонымен қатар материалды тереңірек, әрі берік ұғынуына ықпал ететін, мұғалім мен студенттердің арасындағы ынтымақтастық қарым-қатынастың пайда болуына жол ашты. Проблемалық оқытудағы студенттердің қажетті «бастапқы» білімінің болуы, көп уақытты қажет ету сияқты кемшіліктерге қарамастан, қазіргі таңда проблемалық оқыту идеялары жанартылған білім беру жүйесінде ойдағыдай іске асырылуда.

Кілт сөздер: проблемалық оқыту, проблемалық жағдайлар, білім берудің жаңа технологиялары, химиялық эксперимент, химияны оқыту әдістемесі.

С.Б. Абеуова, Д.Д. Наушабекова, Д.М. Муслимова,
Э.Б. Абеуова, Э.К. Тусупбекова, А.Т. Дюсекеева

Применение технологии проблемного обучения на занятиях по дисциплине «Методика проведения школьного химического эксперимента»

В статье приводятся результаты эксперимента по применению технологии проблемного обучения на занятиях по химии. Проблемное обучение направлено на самостоятельный поиск новых знаний и способов действия, а также предполагает последовательное и целенаправленное выдвижение познавательных проблем, посредством разрешения которых студенты активно усваивают новые знания. Технология проблемного обучения применялась на занятиях по дисциплине «Методика проведения школьного химического эксперимента» с учащимися третьего курса. В качестве проблемных ситуаций в нашем случае были выбраны два демонстрационных опыта по химии. Перед проведением эксперимента проводилась актуализация знаний. Затем идет создание проблемной ситуации и формулировка проблемы. Далее преподаватель показывает химический эксперимент. Учащиеся обдумывают ситуацию, делают выводы. Для диагностики учебной мотивации студентов использовался опросник А.А. Реана и В.А. Якунина, знание проблемных ситуаций оценивалось методом тестирования до и после эксперимента. Для выявления мнения студентов о технологии проблемного обучения проводилось индивидуальное интервью. В результате применения технологии проблемного обучения у учащихся сформировался познавательный и научно-исследовательский интерес, поисковые способности и умения, открылись возможности для сотрудничества преподавателя с учащимися, что способствует более глубокому и прочному усвоению материала. Несмотря на минусы проблемного обучения, среди которых большие временные затраты, наличие необходимого «стартового» уровня знаний обучающихся, идеи проблемного обучения на сегодняшний день успешно реализуются в системах развивающего обучения.

Ключевые слова: проблемное обучение, проблемные ситуации, новые технологии обучения, химический эксперимент, методика преподавания химии.

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