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Formation of students' critical thinking in the process of teaching chemistry

Acquired in the process of Chemistry learning knowledge, skills, achieved development of critical thinking should help students to adapt to the realities of modern life. The main condition for the development of critical thinking is not a presentation of a specific and limited amount of information, but motivation of interest in the Chemistry study, the critical assessment of the proposed theoretical and empirical material by students and then synthesizing them in their activities. The article contains the analysis of pedagogical experiment, where it was established a level of formation of students' critical thinking, as well as a description of some of the techniques and strategies that can be applied in the chemistry lessons.

Key words: critical thinking, techniques and strategies, insert, reflection.

The principal changes that underwent the economy and society, affected the educational system of Kazakhstan, which demanded reforms. These reforms are aimed at the modernization of education, which resulted in all elements of the education system will meet the requirements of modern society. New reforms involve the full development of personality, which is a high school graduate is not only owned a set of subject knowledge, but could apply their knowledge in real life, as well as a graduate should have the skills of self-education, a set of the most important competencies and motivation directed to constant continuing education.

For the implementation of these reforms it is necessary to change the position of a student. For the modernization of education it is necessary to implement a learner transition from a passive entity performing at training a reproductive function in the active object of the educational process that can think critically and creatively.

To implement all the requirements that were presented to graduates, used approaches based on constructivism theory, the essence of which lies in the fact that successful assimilation of knowledge contributes only the knowledge that constructed by the subject of study. Such approaches include technology of development of critical thinking, which aims at self-evaluative thinking, developing by applying the acquired knowledge to their own life experience.

The priority objective of education is its learner-focused orientation, so we need to develop critical thinking, which allows not only to have information, but also to analyze, evaluate, apply it. When studying the new information, students should be able to make their own conclusions about the accuracy and value of the information.

Creation of conditions and the use of various learning tools that can generate students' critical thinking is one of the main tasks of the successful implementation of the modernization of education, so now many educators and psychologists conducted theoretical and empirical search for the creation of these conditions.

Students themselves should set goals and choose ways to achieve them, to use the knowledge acquired at school in real life, beyond the educational process.

The pedagogical experiment was carried out in order to improve student's critical thinking. The experiment involved 10 students of the 10th class of ordinary high school for 3 months. Teaching experiment con-

sisted of three steps: stating, forming and control. During the experiment the different tasks for each stage have been developed that were formative and diagnostic tools.

For stating stage of the experiment there were used tasks, that could be used to set the initial level of critical thinking component. The formative stage of the experiment includes techniques and technology development strategy of critical thinking through reading and writing, which are effective means of developing critical thinking [1]. In the control phase methods of diagnosing of critical thinking levels remained the same, only the content of jobs have changed.

On stating stage of experiment the students were offered different tasks in order to diagnose of development level of critical thinking.

The aim of stating stage of the experiment is to determine the initial level of development of critical thinking of students while learning Chemistry. According to the purpose the main tasks of stating stage of the experiment are allocated:

1. Determine the level of motivational readiness of students to the formation of critical thinking in the study of Chemistry.

2. Determine the criteria and indicators of the level of critical thinking of students.

3. To choose a diagnostic material that can be used to determine the qualitative characteristics inherent to each of the levels of critical thinking.

4. To determine the initial level of development of critical thinking of tenth graders.

5. After analyzing the results obtained in the course of the study, go to the forming stage, where it is necessary to take into account the results of stating stage of experiment.

Consider the criteria for determining the level of development of critical thinking: Low is characterized by a low degree of manifestation of self-control behavior (not know how to listen to others, intolerant of their position, not able to overcome minor complexity; there are difficulties in recognizing their errors and so forth.) and independence in the performance of tasks. The argument is present, but not too convincing — in the struggle of opinions inclined to obey. Creative abilities are rare. Reflective skills are poorly developed (inadequate self-esteem or an inability to look at themselves, to evaluate own actions, including the mental, from the side to find an error in its own mental activity). Activity of student at this level bears meaningful character, but only in operationally-activity aspect. In substantive aspect of pedagogical process the student can misunderstand the structure and measure of manifestations of critical thinking.

Middle is characterized by the expression of sufficiently high self-regulation of behavior (are able to listen to others, tolerant to their position, are able to overcome the difficulties, may recognize their mistake, wrongness, etc.) and independence in the performance of tasks. In most cases, able to think creatively. The reasoning is broad and compelling, in the discussion the student can persuade an opponent to his point of view. Reflective skills are poorly developed (inadequate self-esteem or an inability to look at themselves, to evaluate own actions, including the mental, from the side to find an error in their own mental activity). Activity of student at this level bears meaningful character, but only in operationally-activity aspect. In substantive aspect of pedagogical process the student can misunderstand the structure and measure of manifestations of critical thinking.

High is characterized by a high expression of self-regulation of behavior (are able to listen to others, tolerant to their position, are able to overcome the difficulties, are able to admit their mistake, wrongfulness, etc.) and independence in the performance of tasks. It features a high creative activity. The reasoning is broad and compelling, in a discussion student is able to persuade the opponent to his point of view. Reflective skills are developed at a sufficient level to analyze themselves adequately, objectively evaluate their thinking processes and their behavior during individual or group work on the problem task. Activity of student at this level bears meaningful character, but only in operationally-activity aspect [2].

The stating stage of the study was based on the assumption that in the structure of critical thinking can be identified three components: motivational-targeted, information-activity, analytical-productive. To test these components various tasks were developed aimed at studying of specific component of critical thinking.

At this stage of the experiment students' learning motivation were investigated, the ability of students to make value judgments and level of development of different ways of thinking, which were starting points for the development of critical thinking. The following research methods were used: questionnaires, ability to classification, to reflection, study of students' activities products. For example, to assess the extent of formation of reflective-assessment component of pupils' critical thinking we used text «Zinc» with deliberately inaccuracies.

The results of the study of reflective-evaluative component of students' critical thinking are presented in Table 1.

Table 1

The results of the study of reflective-evaluative component of students' critical thinking

Levels	Number of students	%
High	1	10
Middle	5	50
Low	4	40

From the obtained results, at this stage, it was found that the critical thinking of tenth graders developed insufficiently, although there is a basis for its development.

The purpose of forming phase of the experiment is to test and prove the effectiveness of the methodology developed for the formation of students' critical thinking, using techniques and strategies, proposed the technology of critical thinking development through reading and writing. Tasks of forming stage of the experiment:

1. Development of the method of the experiment using the elements of technology development of critical thinking through reading and writing, promoting development of critical intelligence.

2. Analysis of the influence of methods of technology development of critical thinking on the criteria unit of critical thinking.

After stating stage of the experiment, where the levels of development of critical thinking components have been installed, we proceed to the next stage of our experiment which is formative. At this stage, we need to check the value of developed technique and the probability of the hypotheses put forward at the beginning of the study. In carrying out this stage of the experiment would be appropriate to structure it and identify the successive stages of the experiment:

– the preparatory stage where we need to identify methods and strategies that will be used for the development of critical thinking.

– the main stage, where these techniques and strategies will be tested.

The preparatory stage. For the development of critical thinking among students there are many techniques and strategies. We chose a few, which are not only more popular and can be applied to Chemistry, but also those that are the maximum productive. The techniques used in this method are «Clusters», «Insert», «Conceptual table», «True and false allegations», «Cross-debate», «Cinquain», «Brainstorming», «I know, I want to know — Learned», «Thin and thick questions» [3]. For example, such a strategy as «a conceptual table» (Table 2), helps to organize information, to identify the differences and similarities between multiple objects, to draw parallels between the events and the facts. In turn, such a technique as «Cinquain» allows synthesizing studied material. The simplicity and the multiplicity of forms can help to develop the ability to summarize the information received, to present the information in a few words. «Cinquain» contribute to synthesizing of complex and cumbersome data, evaluating of the conceptual apparatus of students, the development of creativity in presenting their knowledge.

Table 2

A conceptual table on «Sodium, potassium and their properties»

Comparison line	An object of comparison	An object of comparison
	Na	K
Valence level	$3s^1$	$4s^1$
Interaction with oxygen	With formation of Na_2O_2	With formation of K_2O

Method «Cinquain». Making a five-line stanza with a word «zinc».

1. Zink.
2. Hard, plastic.
3. Interact, melt, conduct heat.
4. Zinc is a widely used metal.
5. *d*-element.

The main stage of formative stage of experiment where we need to test these techniques in the study of topics, as well as to explain the cause of the difficulties in the implementation of these strategies in the process.

On the methodical level, this stage is a set of techniques and strategies that cover a variety of learning activities. There are many different strategies; we will consider a few of them in relation to the curriculum in Chemistry in 10th grade. Applying the technology of critical thinking development, the whole lesson can be divided into three parts: the call phase, comprehension stage and the stage of reflection, different strategies applied at a certain stage also can be divided. To each lesson it has been developed a set of technology development techniques of critical thinking, contributing to the formation of critical thinking, as well as the emergence of learning motivation. When teaching students the logic, argumentation of their position, identifying causal relationships we need to give them a «foothold», which in Chemistry is represented as a chemical experiment. In this sense, Chemistry has a huge advantage over other disciplines. All the natural sciences, including Chemistry, use the hypothesis or approval of the experiment as evidence. If we want to form the critical thinking of students, we must enhance the role of the experiment in teaching Chemistry.

On the control stage there is a check of efficiency of applying techniques and strategies aimed at developing critical intelligence.

When selecting diagnostic tools mandatory condition of its use was satisfaction of certain requirements. Firstly, measuring methods should be complementary and mutually check each other. Secondly, obtained during measuring information must clearly express condition of students' critical thinking development, be objective and reasonable. Moreover, it is necessary to take into account the time costs required to carry out measuring of one or another component, as only 2 hours per week have been allocated for Chemistry lessons, so it was necessary to take into account such characteristic as the efficiency of the method. Diagnostic tools remained constant throughout the experimental work, but altered the content of the tests, questionnaires and tasks.

Approbation of methods of critical thinking at students (clusters; correct and incorrect statements; «brainstorming»; graphical techniques) proved the possibility of targeted development of critical thinking at tenth graders in learning Chemistry.

For example, such technique as «Thick and thin questions». This technique can be used on any of the three stages of the lesson, if we use it on the stage of reflection, it will be questions that demonstrate an understanding of the studied material. Table 3 consists of two columns. The first column contains «thin» questions, i.e. those that require a simple, monosyllabic answer. The second column contains «thick» questions, i.e. requiring a detailed and full answer.

Table 3

«Thick» and «thin» questions

«Thin» questions	«Thick» questions
What is plasticity?	Explain why metals conduct heat
Is it true that lithium is the lightest metal?	Why, if in winter to lick metal a tongue sticks to it?

The results of critical thinking testing in the control stage confirm the success of the experiment carried out. For example, so there is a change in the level of development of reflexive-evaluative component (Table 4).

Table 4

The results of a reflexive-evaluative component research of students' critical thinking before and after the experiment

Levels	Number of students	
	Before	After
High	1	1
Middle	5	6
Low	4	3

For illustration the results of the control estimation of the component are presented in Figure.

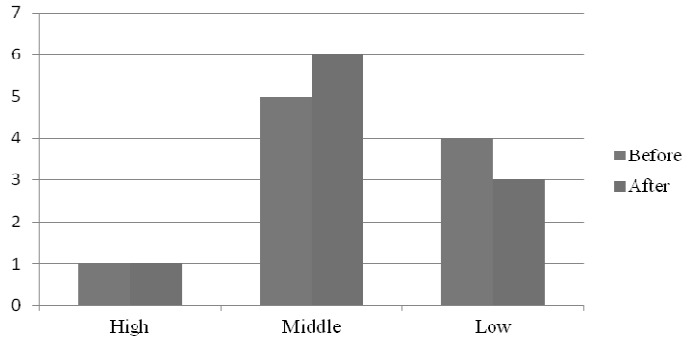

Figure. The results of a reflexive-evaluative component research of students' critical thinking before and after the experiment

Despite the variety of approaches to the study of the problem and opinions of different scientists, there is a common opinion that critical thinking which is developed enough, is an integral part of an effective teaching, good training material possession and use of the information obtained in ordinary life.

At differentiation of the lesson into three stages appears clear algorithm of student and teacher's activity that are pursuing their own motives and goals. Such a division of the lesson does not perform only one function of study, but contributes to the emergence of complex of functions (motivational, informational, communicational, and classificational, evaluation) due to which learning becomes more productive.

There are many techniques and strategies to generate critical thinking. In this paper we have highlighted some of the most popular and productive methods, besides it was necessary to take into account the possibility of its use in Chemistry lessons. Each method allows diversifying the learning process, which often consists of one activity: written or oral. Also, these techniques help to interest more passive students, at whom due course in the learning process may appear personal functions, in particular a motivation to study. When applying these strategies independence of judgment and creativity are developed. If a teacher uses these techniques in the educational process, they may also identify the individual gaps in knowledge of each student.

Having analyzed the results of stating stage of the experiment, it is found that the level of critical thinking at tenth graders is underdeveloped, which tells about the inability of traditional education to develop critical thinking in students at a good level, when students could independently produce new ideas, which are then be possible to put into practice.

Have been determined conditions for the formation of critical thinking, to which we can refer inclusion in the curricula aims of critical thinking development, tasks and exercises aimed at testing of critical intelligence, availability of diagnostic tools that can be used to monitor changes in the development of critical thinking.

To develop critical thinking in students should be used a variety of techniques and methods not only at lessons but also during practical classes where the teacher should provoke a cognitive conflict that helps students to realize the contradiction between their own ideas and observable phenomena. It is also important to ask questions in the course of performing experiments, so that this activity was not mechanical.

When using this program, the teacher is not just a source of new information, but also helps in a quality assimilation of information. Students at lessons take an active position, which leads to a change in personality functions.

Results of the experiment showed improvement in the degree of formation of critical thinking and this is for a short time. At more long-lasting influence and system usage of a variety of strategies, as well as the joint work of teachers of this class, we can achieve a higher level of criticality of the mind.

The technology helps to establish a dialogue between students, through a strategy of «Cross-discussion», «Zigzag». Students take an active part in the discussion, wanting to defend their point of view, at the same time, listening to the position of their opponents. It is important to remind every time about respect of other people's opinions.

In practical activity, a teacher of Chemistry should remember that no one is able to think critically for us, we can only do it for themselves, so the freedom to think for themselves and to solve independently even difficult tasks should be provided for the development of critical thinking of students.

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Химия оқыту үрдісінде білім алушылардың сыни тұрғыдан ойлауын қалыптастыру

Химияны оқыту процесіндегі алынған білім, әрекет, дағдылар, сын тұрғысынан ойлауды дамытуда қол жеткізген ойлау әрекеті оқушылардың бүгінгі күнгі өмірге үйренісуіне септігін тигізуі қажет. Ақпаратты шектелген көлемде және толықтай баяндамау, ал олардың химияны зерттеуге деген ынтасының оянуына итермелеу, берілген теориялық және эмпирикалық мәліметтерді оқушылардың сын тұрғысынан бағалауы және бұдан әрі оларды өз мүддесіне қолдануға жинақтау алуы сын тұрғысынан ойлаудың негізгі шарты болып табылады. Мақалада білім алушылардың сын тұрғысынан ойлауының қалыптасу деңгейін анықтауға жасалған педагогикалық эксперименттің талдау нәтижелері мазмұндалды, сонымен қатар химия сабағында қолдануға болатын кейбір әдістер мен стратегиялар туралы айтылған.

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Формирование критического мышления учащихся в процессе обучения химии

Приобретенные в процессе обучения химии знания, умения, навыки, достигнутое развитие критического мышления должны помочь ученикам в адаптации к реалиям современной жизни. Главным условием развития критического мышления является не изложение конкретного и ограниченного объема информации, а провоцирование побуждения интереса к изучению химии, критического оценивания учениками предложенного теоретического и эмпирического материала и далее синтезирования их в своей деятельности. Статья содержит анализ педагогического эксперимента, где был установлен уровень формирования критического мышления учащихся, а также приведено описание некоторых приемов и стратегий, которые могут быть применены на уроках химии.