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Methodology in chemistry teaching: towards practical class organization in higher school

Metodologia no ensino de química: rumo à organização de aulas práticas na escola superior

Metodología en la enseñanza de química: hacia la organización de clases prácticas en la escuela superior

Olga L. Shepelyuk[1]

[1]Industrial University of Tyumen, Tyumen, Russia.

Corresponding author:
Olga L. Shepelyuk
Email: OShep2019@yahoo.com

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ABSTRACT
This study aims to investigate the problem of organizing practical classes in the disciplines of the natural science cycle at the oil and gas university. One of the unsolved issues is the problem of improving the content of the methodological preparation for conducting the course "Oil and Gas Chemistry" in higher education. It is reported that the logic of delivering the lectures and classes should correspond to the logic of students' assimilation of the subject matter, the formation of skills and abilities, motivation and stimulation of learning, and other components of the pedagogical process. It is spoken in detail about the theoretical prerequisites for developing a methodology for organizing a lesson in teaching the discipline "Oil and Gas Chemistry" on the basis of psychological and pedagogical laws of the algorithmic scheme for constructing a classical lesson in the natural science cycle. The quality assessment of the methodology of structuring the practical lesson proposed by the author was carried out according to the average value of the coefficients Kt or Kp; there was a significant increase, which indicates the effectiveness of the methodology proposed by the author.
Keywords: : Oil and gas chemistry. Training. Lesson. Technique.

RESUMO
Este estudo tem como objetivo investigar o problema da organização de aulas práticas nas disciplinas do ciclo das ciências naturais na universidade de petróleo e gás. Uma das questões não resolvidas é o problema de melhorar o conteúdo da preparação metodológica para a realização do curso “Química do Petróleo e Gás” no ensino superior. Relata-se que a lógica de entrega das aulas teóricas deve corresponder à lógica de assimilação dos alunos da matéria, a formação de

competências e habilidades, a motivação e estimulação da aprendizagem, e outros componentes do processo pedagógico. Fala-se em pormenor sobre os pré-requisitos teóricos para o desenvolvimento de uma metodologia de organização de uma aula de ensino da disciplina "Química do Petróleo e Gás" com base nas leis psicológicas e pedagógicas do esquema algorítmico para a construção de uma aula clássica do ciclo das ciências naturais. A avaliação da qualidade da metodologia de estruturação da aula prática proposta pelo autor foi realizada de acordo com o valor médio dos coeficientes Kt ou Kp; houve um aumento significativo, o que indica a eficácia da metodologia proposta pelo autor.
Palavras-chave: Química de petróleo e gás. Treinamento. Aula. Técnica.

RESUMEN
Este estudio tiene como objetivo investigar el problema de la organización de clases prácticas en las disciplinas del ciclo de las ciencias naturales en la universidad del petróleo y el gas. Uno de los temas pendientes es el de mejorar el contenido de la preparación metodológica para la realización del curso "Química del petróleo y el gas" en la educación superior. Se informa que la lógica de impartir las clases magistrales y las clases debe corresponder a la lógica de asimilación de la asignatura por parte de los estudiantes, la formación de habilidades y destrezas, la motivación y estimulación del aprendizaje, y otros componentes del proceso pedagógico. Se habla en detalle sobre los prerrequisitos teóricos para desarrollar una metodología para organizar una lección en la enseñanza de la disciplina "Química del petróleo y el gas" sobre la base de las leyes psicológicas y pedagógicas del esquema algorítmico para la construcción de una lección clásica en el ciclo de las ciencias naturales. La evaluación de la calidad de la metodología de estructuración de la lección práctica propuesta por el autor se realizó de acuerdo al valor promedio de los coeficientes Kt o Kp; hubo un aumento significativo, lo que indica la efectividad de la metodología propuesta por el autor.
Palabras clave: Química de petróleo y gas. Formación. Lección. Técnica.

INTRODUCTION

To obtain a modern basic education for future work in the oil and gas sector, students must master the complex knowledge of the natural science cycle, including knowledge of oil and gas chemistry, an important engineering education component (Enzai et al., 2021).

To date, the methods of teaching chemistry in secondary and higher schools, which ensure the fulfillment of their professional functions, have in many ways already been developed. Contributions to the development of its various aspects have been made (Khamitova & Ivanov 2006; Dendeber 2007; Pak 2012; Ogorodnik & Arshansky 2014) and others. However, the problems of theoretical training of higher education teachers in this area have not been resolved. Among the unsolved problems is the problem of improving the content of the methodological preparation of the course "Oil and Gas Chemistry." This aspect's imperfection is evidenced by a number of studies (Pavlov 2015; Uryadnikova et al. 2020), which revealed that teachers had poor methodological training, a lack of skills in structuring theoretical and methodological material, insufficient skills in organizing problem situations in the lesson, etc.

The study of the state of didactic training of teachers of higher education showed that teachers have difficulties in solving many important issues of building a lesson: there are no clear criteria for justifying the necessary composition of elements of the lesson and, accordingly, the choice of its type, in the inability to coordinate the tasks of the elements of the lesson with the tasks of the stages of mastering the educational material. Teachers associate methodological development of lessons mainly with the structuring of educational material and description of the sequence. Simultaneously, the logic of conducting classes should correspond to the logic of students' assimilation of academic subjects' material, the formation of skills and abilities, motivation and stimulation of learning, and other components of the pedagogical process (Afanasiyivna, 2017;

Rahmat et al., 2021).

A lesson in a technical university is built on the basis of the laws operating in teaching (Ibragimov 2008; Shepelyuk, 2019). The guideline for the methodological construction of the lesson is its structure, which, in turn, should reflect these patterns.

Since the existing general concepts of the structure of the lesson do not give an idea of the mechanisms of applying the regularities when constructing a lesson in the discipline "Oil and Gas Chemistry", there is a need for a more thorough study of this issue.

The purpose of our research is to develop a methodology for organizing a lesson in the discipline "Oil and Gas of Chemistry" based on the psychological and pedagogical laws of the methodology for constructing a classic lesson in the natural science cycle.

METHODOLOGY

Considering the lesson organization methodology's basic concepts, since substantiation of one or another component of the "lesson" system will be the basis for the emergence of an appropriate concept for the structure of the lesson in our discipline.

The variety of studies of the concept of "lesson" is clearly illustrated by definitions of the lesson given by different authors.

The modern lesson is presented as a system, in its entirety, which consists of its main aspects: content-target, organizational-practical, and control-evaluative (Ermolaeva 2011).

Kulnevich S.V., & Lakocenina T.P. note that the lesson is a dynamic system and variable form of organization of the educational process, should be carried out in accordance with the requirements of the curriculum, provide educational and cognitive activities of students, be a logically complete element in the educational process (Kulnevich & Lakocenina 2002).

Grishova E.A., in the concept of a modern lesson, notes a shift in emphasis on the results of mastering the main educational program. The author argues that all educational activity should be based on the activity approach, the purpose of which is to develop the student's personality on the basis of mastering universal methods of activity. A child cannot develop with the passive perception of educational material. His own action can become the basis for the formation of his independence in the future. This means that the educational task is to organize conditions that provoke children's action (Grishova 2016).

Yakushina, E.V. Notes the influence of new standards on the structure of the lesson, where real activities, their implementation, and the formation of key competencies are a priority (Yakushina 2012).

But despite the new standards introduced by FGOS 3, FGOS 3 ++, for all the diversity of the concept of "lesson", this concept can be noted as an organizational form of training, including such components as purpose, objectives, content, methods, and means of teaching, as well as time and place, level of preparation in secondary school and age of students.

Therefore, the main requirement that any lesson must satisfy is the observance of all components, which must reflect all the main components of the learning process (Slastenin & Kashirin 2006).

But some aspects of the learning process in the classroom are not fully reflected in the teaching methodology for special disciplines, for example, the teaching methodology for "Oil and Gas Chemistry." The basis for identifying the components of the structure of the lesson in this discipline is the activities of students, the practical component of the educational process.

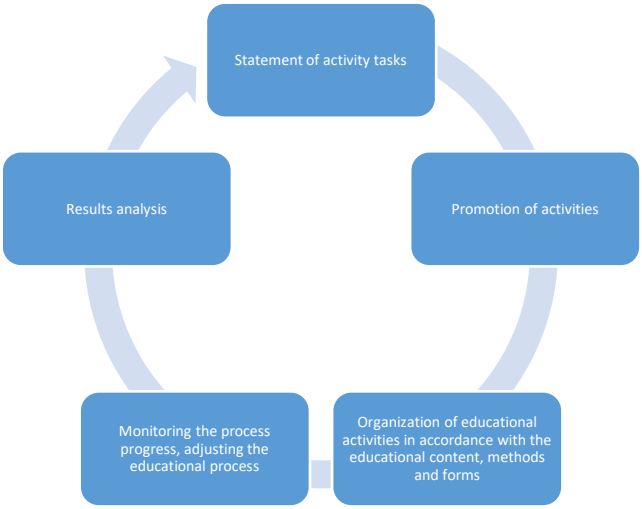
We agree with M.M. Levina, who distinguishes two components that characterize the teacher's activity - teaching and that characterize the student's activity - learning. Moreover, the components of the lesson: the activities of the teacher, and the activities of the student, in the concept of M.M. Levina, combine all the other components of the learning process (Levina 2001).

The learning process is one of the types of human activity in which two roles function - the learning activity is conditioned by the participation in it, on the one hand, of the teacher, and on the other, the learning activity. The activity of the teaching consists in mastering some kind of educational material, in particular: modern ideas in the field of oil and gas chemistry, the formation of their knowledge in matters of the origin of oil, analysis of oil and oil products, preparation and processing of oil and gas, and the purpose of teaching is, so that students can master this teaching material.

The result of the study is the mastery of a certain level of knowledge, skills and abilities of the basic theoretical and practical concepts of the chemistry of oil and gas, consideration of the physicochemical properties of oil hydrocarbons and methods of their modern research, oil dispersed systems.

The processes of teaching and learning in a technical higher school are different since the practical part takes 60% of the study time, which requires the teacher to develop, search for new modern means to ensure the flow of the pedagogical process in the discipline "Oil and Gas Chemistry." (Fig. 1).

Figure 1. Stages of a practical lesson in the discipline "Oil and Gas Chemistry".



The educational activity of students consists of goals, educational material, active implementation of educational activities.

The selection of two types of activities in this process allows us to structure and implement them in the lessons of oil and gas chemistry to develop teachers' and students' interaction with the goal of final results.

In order to develop a methodology for organizing a lesson in the discipline "Oil and Gas Chemistry" on the basis of psychological and pedagogical regularities of the methodology for constructing a classical lesson in the natural science cycle, we need to highlight such elements of the learning process that show the activities of students' teaching, such as the functioning of elements of learning activities in certain conditions, reflecting its essence.

RESULTS AND DISCUSSION

Analysis of the work program for the discipline "Oil and Gas Chemistry," studied in the Surgut branch for students of the direction "Oil and Gas Business," shows that their content has a certain structure. The educational material is divided into several large blocks, studied sequentially. Each

block of educational material corresponds to certain tasks' solution, the implementation of competencies, which in their totality constitute a relatively integral, logically completed part of the course being studied. When studying the block's educational material, competencies are implemented, aimed at the formation of complex knowledge, abilities, and skills in the specialty. Therefore, the study of blocks in a different sequence than that provided by the program often distorts the logic of constructing the academic subject itself.

The relationship between the content of such blocks is diverse. It can be different depending on the semester. In the first semester of the discipline, the course has a linear character (the material of each subsequent block is directly related to the previous one and indirectly with the content of the blocks studied even earlier), in the second semester, it is branched (the educational material of the studied blocks interact with the study of the educational material with which they are connected on the interdisciplinary level).

For example, the topic "Physical and chemical properties of oil and oil products" contain a certain range of issues: physical and chemical properties of oil and oil products, the fractional composition of the oil, classification of oil to be studied and determined by the curriculum. We see that the content of the lesson combines several questions of the educational material. At the same time, it itself is part of the educational material of the topic section. Therefore, the lesson cannot be regarded as an isolated part of the educational process at the university,

Based on the above provisions, we consider the lesson on the discipline of oil and gas chemistry as an integral system, consisting of several components that are not identical in their characteristics and interconnected.

The lesson's internal structure is formed by the elements of the learning processes, highlighted on the basis of the processes of assimilation of knowledge, skills, and abilities. The elements of the lesson's internal structure include elements with cognitive processes of transmission and assimilation of the content of educational material based on the activities of teaching and learning in teaching. It includes:

- the formation of new knowledge: characteristics of the chemical process (phenomenon), characteristic of the objects of professional activity, based on experimental research; technologies for conducting typical experiments on standard equipment in the laboratory and in production; technologies for processing the results of research activities using standard equipment, devices, and materials; basic information about the objects and processes of professional activity through the use of professional terminology; methods or techniques for solving the problem of professional activity; regulatory and legal and technical documents governing activities in the field of oil and gas production to solve the problem of professional activity; principles of drawing up reports, reviews, inquiries, applications, and other documentation, based on the real situation;

- the formation of skills and abilities: to determine the characteristics of a chemical process (phenomenon), characteristic of objects of professional activity, based on experimental research; the skills of determining the characteristics of a chemical process (phenomenon) characteristic of objects of professional activity, based on experimental research; choose technologies for conducting typical experiments on standard equipment in the laboratory and in production; the skills of choosing technologies for conducting typical experiments on standard equipment in the laboratory and in production; to process the results of research activities using standard equipment, devices and materials; skills in processing the results of research activities using standard equipment, instruments and materials; describe basic information about the objects and processes of professional activity through the use of professional terminology; the skills of describing basic information about the objects and processes of professional activity through the use of professional terminology; choose methods or techniques for solving the problem of professional activity; the skills of choosing a method or technique for solving the problem of professional activity; choose legal and regulatory documents regulating activities in the field of oil and gas production to solve

the problem of professional activity; skills in the selection of legal and regulatory documents regulating activities in the field of oil and gas production to solve the problem of professional activity; draw up reports, reviews, certificates, applications and other documentation based on the real situation; skills of drawing up reports, reviews, inquiries, applications and other documentation, based on a real situation.

In addition to these components, the internal system includes motivation, stimulation, control, and adjustment.

The lesson's external structure consists of elements that are a combination of internal components: the beginning of the lesson; check of knowledge; work on new educational material; primary consolidation of new material; delivery of homework, end of class (Snopkova 2018).

Let us consider the methodology for conducting a practical lesson on the discipline "Oil and Gas Chemistry" at the TIU branch in Surgut in accordance with the diagram Fig.1. Since it is the examination of the elements separately that allows us to see in each of them the whole set of processes occurring in the lesson...

The first stage of the beginning of the lesson suggests showing the presence in this element of motivation and stimulation of learning, testing of knowledge. Let's consider this stage using the example of the topic of the practical lesson "Determination of Oil Content in Water." At the beginning of the lesson, there is a frontal survey of students on the theoretical educational material. Students should clearly present educational material: dispersed systems, their classification, the formation of emulsions, their classification, aggregate stability of oil emulsions. Emulsion stratification rate, Stokes equation; pavilion, structure, classification; adsorption of paving stones on micelle surfaces; methods of destruction of oil emulsions. The mechanism of action of demulsifiers; what do oil and water solubility of demulsifiers depend on? Why do they remove water from oil? Stages of oil preparation.

The components of motivation and stimulation of learning are carried out through the creation of a problem situation, arousing in students an interest in participating in solving the problem: determining the oil content in water. The form of work chosen by the teacher on the material covered in the form of laboratory or practical work is the incentive that contributed to the acceptance of the goals of this stage of the lesson by students. The concept of the formation of new knowledge appears in this example in the form of systematization of existing knowledge.

The stage of formation of skills and abilities occurs through the application of the acquired knowledge in solving practical tasks: to determine the volume percentage of water in crude oil by the centrifugation method.

Task: Pour a sample of homogenized oil into ten centrifuge tubes up to the top mark (10 ml). With each demulsifier, the water content in two samples is determined, and their average value is taken to fill in the table. Number the tubes. Add two drops of Dissolvan 4761 demulsifier into two-second tubes, two drops of Sondem 4401 demulsifier into two third tubes, two drops of "EC-135" demulsifier into two fourth tubes, add one drop of "Sleep" to the fifth tubes -dem 4401 "and one drop of" Dissolvan 4761 ". Place the tubes in centrifuge wells located diametrically. Close the centrifuge and plug it in.

Open the centrifuge after the rotor has come to a complete stop!

First centrifugation time 5 minutes. Note the amount of water in the samples. Then centrifuge for another 5 minutes. Check the separation of emulsions in tubes; note the changes. The time for the third centrifugation is also 5 minutes.

Centrifugation is considered complete if there is no difference in the volume of water received between the second and third determinations. Enter the received data in table 1.2.

Calculate the water content using the formula:

$$C_{\%} = \frac{V_{воды}}{V_{эм.}} \cdot 100\%$$

Assignment: Draw conclusions about the effectiveness of the demulsifies, noting with which of them there was a complete extraction of water.

The control has the function of determining students' level of knowledge in the past material, skills, and abilities of students related to the application of knowledge in the past material. On the part of the students, it manifests itself mainly in self-control; for this purpose, questions for self-control are offered at the end of the lesson. The process of making adjustments is ongoing, based on the information collected during the control process. Processes that go beyond the accepted framework are adjusted as necessary. The introduction of corrective actions on the processes can be carried out directly or indirectly through the conditions of their course

The stage of work on new theoretical educational material is carried out by means of explanation using various means of visualization.

For example, when studying the determination of the density of oil, the teacher provides a table and diagrams of classifications of oil by density, classification according to the proposal of the XI International Petroleum Congress; classification in accordance with GOST 31378-2009. Oil. General technical conditions.

The stage of consolidating the new material is to organize the practical part of the lesson. For example, determine the mass percentage of water in oil using the Dean and Stark method. Students are provided with equipment: 1. Heating mantle; 2. AKOV apparatus, measuring cylinder for 100 cm3; 4. glass rod; 5. solvents - toluene; 6. boiling water (pieces of pumice, porcelain, glass capillary tubes). The teacher draws up an algorithm for solving this practical task, and the students calculate the volumetric percentage of water using the formula. Motivation and stimulation of learning at this stage are expressed in the practical application of theoretical material, the possibility of a clear example of connection with life in their future professional activities (Ibatova & Shepelyuk 2017).

Motivation reflects the mutual activities of the teacher and students in order to accept the goals of learning. This component refers to the actions of the teacher and students to develop in them certain motives for the upcoming educational activities to meet cognitive and social needs. 96% of students note the huge role of cognitive needs and motives in teaching oil and gas chemistry. Cognitive motives dominate in the educational process of the lesson at the beginning of the lesson, when students get acquainted with the purpose of the practical lesson and should be supported by the teacher throughout the lesson, as they activate the activities of students in the lesson, increase its individuality and independence. These types of motives are caused by certain stimuli, depending on the personality and activities of the teacher, associated with the purposefulness of students, associated with an interest in the very process of mental activity, based on a formed worldview, conviction. As we have already mentioned, the focus of training is of great importance, especially the professional one.

The analysis of academic performance results and methodological guidelines developed at the Department of Natural Sciences and Humanities of TIU branch in the city of Surgut in compliance with all stages of the lesson showed that students clearly understand the goals of these elements. But, in the proposed methodological construction of the elements of the lesson structure, there are differences, which are expressed not by the same consideration of technological requirements for teaching the cycle of chemical disciplines and by different approaches to organizing the learning processes in the lesson. The quality of the developed methods of conducting the elements of the lesson was assessed by the coverage of the number of technical requirements for teaching. Assessment of the quality of the methodology for organizing a lesson in the discipline "Oil and Gas Chemistry" on the basis of psychological and pedagogical regularities of the methodology for constructing a classical lesson in the natural science cycle was carried out according to the average value of the coefficients:

$$Kcp = \sum Kt\ (k)i : I \qquad (1)$$

Kav - the average value of the coefficient Kt or Kp, (k) i is the value of the i-th coverage coefficient, i is the number of techniques for conducting the lesson's components.

The average coefficient was calculated based on the following formulas. $K_t = n_1 : n_0$, where K_t is the coefficient of coverage of technological requirements for teaching in the methodology of the lesson element, n_1 is the number of technological requirements for teaching taken into account in the developed methodology of the lesson element, N_1 is the maximum number of technical requirements for which the methodology of the lesson element was evaluated ($n_0 = 8$), taking into account the components of the lesson structure: $K_p = m1 : m0$, where K_p is the accounting factor for all the components of a classical lesson, m1 is the number of components of the lesson structure, specially organized in the methodology of the lesson element, m0 is the maximum number of components organized according to the developed concept lesson structure ($m_0 = 5$).

On the basis of mathematical data processing, we found out that the use of different concepts of the lesson structure does not affect the formation of students' knowledge at the first stage of the lesson; here, K_p increased by only 0.2 units. A significant increase was observed at the stage of work on new teaching material by 0.5 units. An increase in the value of the coefficient reflects the better formation of a systematic view of the lesson methodology, compliance with all organizational requirements, particularly the substantive part. Accounting for the material support of practical training, Kp is increased by only 0.7 units. This situation should be explained by the fact that students better represent their activities in the classroom when using visual aids and in the presence of practical, experimental art in the classroom, "Oil and Gas Chemistry." A slight increase was observed at the stages of fixing the new material, control, and self-control.

Thus, the experiment showed that the study of the structure of the lesson and the observance of all components of training leads to their better organization in the methods of the elements of a theoretical lesson, characterized by an increase in the coefficient of accounting for the coverage of all components of the structure of the lesson.

CONCLUSIONS

In general, the teaching of the discipline "Oil and Gas Chemistry" is based on the knowledge base in psychology, pedagogy, and special technical disciplines' methodology. Therefore, the methodological preparation of classes in chemical disciplines in higher education depends on how purposefully future engineers in their professional activities will apply these subjects' knowledge. One of the ways to improve the teaching of chemistry disciplines was to develop and study many specific recommendations and techniques for the lesson. However, practice shows that teachers often perceive these teaching materials as instructions, which leads to the suppression of students' creation, the creative beginning of the pedagogical process, and the formal application of methodological instructions by students of our university. Therefore, we believe that the constant improvement of the methodology for conducting different types of lessons, various modern pedagogical tools that orient teachers and students towards the purposeful, integrated use of acquiring new knowledge, is a vector for improving future engineers' training in the oil and gas sector.

In this research, a study was carried out on one of the aspects of this problem - the development of a methodology for organizing a lesson on the discipline "Oil and Gas Chemistry" based on psychological and pedagogical laws of the methodology for constructing a classic lesson in the natural science cycle. The study of this problem has shown that the new methodological solutions proposed by other teachers for constructing lessons and us are associated with the algorithmic scheme of a classical lesson, which is only a vector for the teacher to interpret it and should direct the teacher only to adhere to a certain sequence adopted in their characteristics. The

teacher chooses the forms and means of classes depending on the situation, which is such a characteristic of the pedagogical process as flexibility. Therefore, we have developed a set of components for teaching the discipline "Oil and Gas Chemistry" in the classroom as the main directions of the organization of teaching, stages: the formation of knowledge, skills, motivation, and stimulation of learning, building a lesson, studying the topic, etc. At the same time, we took into account the technical educational institution and teachers' personal experience to improve the quality of teaching chemical disciplines. The introduction of the developed provisions confirms this study's reliability into the practice of teaching the textbook "Chemistry of Oil and Gas. Laboratory workshop for students in the field of training 21.03.21. "Oil and Gas Business" in 2019 (Shepelyuk 2019).

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