Chemical Demonstration Experiment as a Means of Forming Professional Competence of Engineering Specialties Students

Olga Shepelyuk
Tyumen Industrial University, Russia

ABSTRACT

In the article the author describes the algorithm for conducting a demonstration experiment on discipline "Oil and Gas Chemistry". This chemical experiment algorithm is used in teaching students of indener specialties at Surgut Oil and Gas Branch of IUT. The author analyzes the existing pedagogical experience in education on this issue and indicates the necessary requirements for conducting a chemical experiment in the framework of new educational technologies and in the context of educational programs, goals and objectives of vocational education in higher education.

Keywords: experiment, demonstration, presentation, educational material.

1. Introduction

In the process of teaching chemistry teaching, significant theoretical and practical experience of teachers has been accumulated in the use of many methods and methods in the study of chemistry.

Many teachers focus on the effectiveness of the use of various chemical experiments in the methodology and experience of teaching chemical disciplines in the practice of higher education and education in general.

Verkhovsky V.N. describes the demonstration experiment as a special way of teaching chemistry. The source of the knowledge gained by the student, the means of preventing mistakes and misunderstanding of the students, the correction of knowledge, how to check the truth, the hypothesis presented by the teacher, the solution of the educational problem (Verkhovsky, 1960).

Demonstration of experiments not only arouses interest in the subject, but also activates the thinking, memory and attention of students (Zhlin, 2012).

Thinking is a process of conscious reflection of reality in such objective properties, connections and relations, which include objects inaccessible to direct sensory perception. Attention is the direction and concentration of consciousness on certain objects or any activity. Memory is the ability of the nervous system, more precisely, the brain, to perceive the reality around us, to imprint it in nerve cells, to store the perceived information in the form of traces of impressions, and then, as necessary, to reproduce or name them. Memorization is one of the processes of memory, meaning the introduction of newly received information into memory.
Studying such an important issue as the process of thinking, it is important to understand that thinking unfolds in time as a process, even if it seems that its result is manifested almost instantly. Therefore, it is necessary to study the internal causes that lead to the achievements of certain products of thinking. The driving force of thinking is contradictions (between the goal and the means at the disposal of the subject, etc.) (Gilmanshina, 2014).

In preparation for this lesson, you should familiarize yourself with the types of thinking. They are divided according to their content: into concrete-effective, visual-figurative, abstract; by the nature of the tasks being solved: practical and theoretical; according to the degree of novelty: reproductive and creative. It is advisable to think in advance about examples illustrating theoretical statements concerning different types of thinking. The world in which a person lives constantly influences him with many sides, but only part of what is happening around him is in consciousness. This is the manifestation of the selective nature of our knowledge. We distinguish the words of the interlocutor, although other people speak nearby, we notice in the crowd a person waving at us. At the same time, we try to focus on something important to us, peer, listen attentively. This is where our attention is manifested. Attention is the focus and focus of consciousness on certain objects or any activity. When studying attention, it is important to understand the types of attention. External attention is drawn to the external world surrounding a person. The inner is directed to his own thoughts and experiences. Depending on the expression of the target orientation and the level of necessary volitional efforts, involuntary (unintentional) and voluntary (intentional) attention are distinguished. After-spontaneous attention occurs when work absorbs a person so much that interruptions in it can even be annoying, since after them you need to be drawn back into the process (Gilmanshina, 2014).

In combination with such methods of teaching oil and gas chemistry at the university, as the creation of problem situations, the use of practical exercises, seminars, and especially demonstration experiments, it allows to achieve a high level of mastering and authorization of skills, it allows students to carry out reproductive activity in practical classes using such methods, as thinking, comparison, proving hypotheses.

Despite the rapid development of the oil and gas industry in recent decades, the new nature of the course in the discipline "Oil and Gas Chemistry" makes it necessary to reduce the amount of factual material and, consequently, the number of lecture demonstration experiments. The role of demonstration experience in this regard, however, does not decrease, but rather increases.

At Surgut branch of IUT, students of technical specialties studied the chemistry of oil and gas for 2 semesters until 2020, starting from 2020, the chemistry of oil and gas was reduced to one semester. During the implementation of this program, it turned out that the teacher has to spend the bulk of the study time on eliminating the gaps in school science education, which has recently become worse and worse. The teacher should devote several lessons to the repetition of the school chemistry course, the basics of physics and mathematics. Teachers note that many students do not master the university chemistry course. Students are forced to study the most difficult sections of the discipline briefly. The content of the course material must be taught in one semester. As a consequence of this, from the number of demonstration experiments we had to exclude experiments that require complex installations and a long time to conduct, and select such experiments that are suitable for illustrating new principles and new generalizations.

We are forced to carry out systematic work on the selection, improvement and verification of experiments in the chemistry of oil and gas according to the following criteria: visibility, comprehensibility, effectiveness, and quality of assimilation. Experiments should be "not only instructive and correct, but even beautiful and attractive." The experience should be visual, convincing, effective.

Therefore, the purpose of our research is to develop an algorithm for conducting a chemical demonstration experiment in order to activate thinking, memory, imagination of students.

Methodology

The problem of developing a methodology for conducting experiments was dealt with by many teachers from various fields of research.

Nazarova T.S., Grabetsky A.A., & Lavrova V.N. devote to the issues of material ensuring a chemical experiment and its impact on scientific and technical progress on training equipment, as well as the methodology and technique of conducting a chemical demonstration experiment in the classroom (Nazarova, et al, 1987).

Dobrotin D. Yu. Considers the main approaches to the definition of the concept of experiment and chemical experiment, characterizes and clarifies the main functions chemical experiment, the author gives examples of the use of various types of chemical experiments in the classroom (Dobrotin, 2017).

Turchen D.N. determined the place and prospects of a chemical experiment in high school, the author noted changes in education associated with dynamically changing a world in which not just knowledge comes to the fore, but "knowledge in action" (Turchen, 2014).

A.K. Grabovoi considers and characterizes a chemical experiment as
method, teaching and visualization tool (Grabovoi, 2013). Zhilin D.M. showed a method of using a chemical experiment to form critical thinking, which is based on the concept of falsification of theories and consists in organizing a cognitive conflict (problem situation) (Zhilin, 2012).

Zhakyshova B. Sh., & Moldoshev A. M. consider in practice the application of a "chemical experiment" in the learning process chemistry, prove that a demonstration experiment contributes to the study of various properties of substances, the study of the mechanism of occurrence and external manifestation of signs of chemical reactions (Zhakyshova & Moldoshev, 2016).

Safarova M.A. & Karpenko G.M. summarize information on the use of experimental work of a different nature in chemistry lessons and in extracurricular activities. The authors suggest possible topics of research and home experimental work (Safarova & Karpenko, 2013).

Analyze of foreign teachers experience.

So, YANG X. D., ZHANG Y. H., ZHOU Y. M., & ZHOU Y. M. propose a method for creating an open chemical experimental laboratory and the effects of opening experiments in teaching university students. The authors argue that this approach contributes to the formation and development of students' creativity and the development of their practical abilities and experimental technique (YANG, et al, 2007).

Rongxiu F., Hongyu G., Liping F., & Ximing S. They propose an innovative teaching system that is built on a series of experiments to empower students and to increase their comprehensive development and understanding of various fields of knowledge. The authors argue that this system requires more advanced capabilities, automated skills in experimental learning. In this way, both teachers and students can improve their competencies and abilities (Rongxiu, et al, 2010).

Zhengde, T., Yuan, C., & Bing, Y. They talk about the shortcomings of this teaching method, about the problems that teachers have in the pedagogical process. Theoretical knowledge, practice, innovation can combine theoretical knowledge and scientific research, so that practical ability is transformed (Zhengde, et al, 2009).

SHI YF, LI, Q., & ZHANG YL also declare the relevance of chemical experiments in chemistry education, which is an important part of the curriculum, in their work, the authors have conducted active research on how to improve students' ability to conduct experiments, develop experimental abilities, and how improve the quality of teaching chemistry in the pedagogical process (SHI & ZHANG, 2009).

Jiandong Z. proposed the conditions under which students could prepare for experimental experiences and develop practical and laboratory skills, which would improve the quality of teaching and meet the needs for the development of innovative and applied skills (Jiandong, 2010).

Analysis of the pedagogical literature indicates the relevance of our research, after a long study of the theoretical base, it is necessary to consolidate the knowledge and make a semantic pause, which will improve the assimilation of knowledge of the chemistry course, in this way we are helped by a chemical demonstration experiment.

We have developed an algorithm for conducting a chemical demonstration experiment in order to activate thinking, memory, imagination of students. The experiment involved 52 first-year students of the Surgut branch of the IUT, the study was carried out during 2019-2019.

In the course of the research, the following methods were used: pedagogical experiment, analysis, synthesis of information, mathematical processing of information.

Results

The methodology developed by us for conducting classes using a demonstration chemical experiment provides a high degree of clarity of theoretical material, which can prepare students for conducting laboratory work or experiment independently or under the guidance of a teacher.

Each lesson on "Oil and Gas Chemistry" includes a theoretical part, a chemical experiment, examples of solving problems on the topic under consideration and questions for self-control to test tasks.

When introducing theoretical material, we use such a demonstration method as presentations. There are certain rules for conducting visualization lectures. Such presentations contain: text information; textual diagrams (logic diagrams); information tables; mathematical, chemical and other formulas, equations; diagrams, drawings, graphs, photographs of devices, objects; demonstration of phenomena and processes, operation of devices, etc. (Rozhdestvenskaya, 2015).

We have determined the proportion of information in each slide.
Table 1. Type of information when introducing theoretical material in a presentation

<table>
<thead>
<tr>
<th>Type of information</th>
<th>Share of information type (%)</th>
<th>The amount of information type in the presentation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>formulas, equations information tables</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>text, text logic diagrams</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Additional materials</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>diagrams, pictures, graphs demonstration of processes</td>
<td>50</td>
<td>60</td>
</tr>
</tbody>
</table>

Consider the theoretical material taught by us in the course "Oil and Gas Chemistry" for engineering students at the IUT branch for first-year students. The amount of material on the topic "Determination of the Physical and Chemical Properties of Fuels" may vary from its content and purpose. The purpose of this lecture is to determine a number of physical and chemical indicators of motor fuels, comparing their indicators with regulatory documents.

The presentation includes textual material that the fractional composition of gasoline characterizes the volatility of the fuel (10, 50, 90% distillation), which depends on:
- engine start, speed of its warming up
- fuel distribution on cylinders
- completeness of fuel combustion

The boiling point and boiling point of 10% of the distillate characterize the starting properties of the fuel, the boiling point of 10% of the fraction must have a certain lower limit (in GOST the temperature is indicated at most), because at temperatures below this limit, jams form in the engine supply system. The pressure of saturated vapors depends on this temperature: the lower it is, the higher the pressure, which affects the physical stability of the fuel (evaporation during storage and transportation)

The boil-off temperature of 50% of the fraction characterizes the quality of mixture formation in a heated engine, the speed of the engine transition from one mode to another, the distribution of gasoline fractions over the cylinders, and the engine warm-up rate.

The temperature of 90% of the distillate affects the completeness of fuel combustion and carbon deposition in the engine cylinder; at high values of these temperatures, gasoline does not have time to completely evaporate and enters the cylinders in liquid form, which leads to incomplete combustion of fuel and washing off the lubricant.

The term chemical stability is the ability of gasoline to resist chemical changes during storage, transportation and use (check by the induction period, the longer, the higher the stability of gasolines). There are permissible storage periods for gasoline depending on the tanks (ground, buried, semi-buried and car tank) and climatic zones. So, in a buried tank in the northern zone - 36 months, in a car tank in the southern zone - 3 months.

The freezing temperature of gasoline is below -60 °C, this parameter is not considered in GOST.

The octane number (RON) of gasolines characterizes the detonation resistance of fuels (detonation is an explosion); knock resistance - the ability of fuel to burn in the cylinder of an engine with forced ignition without explosion. The octane number of n-heptane is taken to be zero, its ignition occurs explosively, the flame front moves at a speed of up to 2000 m / s.

The main formulas included in the theoretical material:

\[
CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3
\]

Fig. 1. The octane number of isoctane (2,2,4-trimethylpentane) is taken to be 100, i.e. its ignition occurs smoothly, the movement of the flame front is 15 - 60 m / s.

\[
\begin{align*}
CH_3 \\
CH_3 - CH_2 - CH - CH_2 - CH_3
\end{align*}
\]

Fig. 2. The flammability of diesel fuel is characterized by the cetane number, cetane (n-hexadecane C16H34) has a short autoignition delay period and its CN is taken to be 100, α-methylnapthalene has a long autoignition delay period, its CN = 0.
The central frequency of engines is taken in the range of 40 - 50. A larger number is impractical due to a slowdown in the completeness of fuel combustion, a smaller one due to a delay in the autoignition period.

The tables include educational material: types of petroleum products, volatility of gasoline, GOST 32513-2013 [16] motor fuels. Unleaded gasoline, technical conditions, GOST 305-2013 [17] diesel fuel, technical conditions, parameters determined by the SHATOX SX-300 device and etc.

The fundamental prerequisite for the experiment is the main instruments:

1. hydrometers;
2. viscometers;
3. chemical glassware;
4. octane meter.

Technical capabilities of these devices:
10. Identification of the brand (manufacturer) of engine oil;
12. Measurement of dielectric constant of petroleum products;
13. Measurement of specific volumetric resistance of petroleum products;
7. Induction period of gasoline oxidation (oxidation stability);
5. Determination of the amount of engine oil in gasoline;
1. Determination of octave numbers of motor gasolines;
3. Determination of the limiting filterability temperature and the type of diesel fuel;
2. Determination of cetane numbers of diesel fuels;
14. Determination of the content of mechanical impurities in oil products;
4. Content of antiknock metal-containing additives that increase the octave number in gasoline;
15. Water content in oil products. According to “GOST 14203-69 Oil and oil products. Dielectric method for determination of moisture”.

6. Content of kerosene in diesel fuel;
9. Degree of purity (purification) of oils: motor, industrial, transformer;
8. Tangent of loss angle of transformer, industrial and motor oils;
11. The base number of engine oils.

On this topic, we have compiled an algorithm for a demonstration experiment, which, in our opinion, clearly allows us to determine a number of physicochemical indicators of motor fuels, compare their indicators with regulatory documents.
A. It is necessary to select a sample of the analyzed oil product, determine the density of the oil product at the temperature of the experiment and recalculate it according to the Mendeleev’s formula for density at 20 °C.

B. The next step is to determine the kinematic viscosity of the oil product at 20, 30, 40 °C and calculate the dynamic viscosity. Students must prove that viscosity versus temperature is linear.

C. Then we determine the parameters with the SHATOX SX-300 device. Connect sensor 1 or 2 to the corresponding octane meter connector. To carry out the measurement, pour 75 ml of the investigated oil product into sensor 1 or 2, switching the operating modes of the device, then write down the readings of the device.

D. After that, pour the fuel sample into the original container, after analyzing diesel fuel, kerosene or oil, the sensor must be washed with gasoline.

E. Fill in the table “Results of analysis of a sample of petroleum products”, which includes such indicators as: density, kg / m³ viscosity; kinematic, m² / s; dynamic, MPa · s; octane number (for gasoline) mm; im; ai; cetane number (for diesel fuel); the content of kerosene in diesel fuel; metal-containing additives in gasoline; water content, %.

Fig. 1. Algorithm of a chemical demonstration experiment

During a demonstration chemical experiment, the teacher needs to fix the attention of students at all stages. The teacher needs careful preparation for such activities, which requires repeated execution of experiments, during which students acquire skills in handling chemical utensils and reagents, work out the method of calculating and preparing solutions, the necessary concentrations, learn to plan an experiment, get acquainted with the properties substances. Such work fosters independence, activity and responsibility for the assigned task in students, instills interest in the subject, improves the quality of knowledge and forms a conscious attitude towards safety rules.

Conclusion

Thus, the algorithm developed by us for carrying out a chemical experiment is an effective method of forming skills to solve problems related to professional activities, applying methods of modeling, mathematical analysis, natural science and general engineering knowledge and to measure, process and present experimental data.

The application of the method of the demonstration chemical experiment allows to activate the cognitive activity of students, which contributes to the active growth of the quality of education and the success of students in the discipline “Chemistry of Oil and Gas”. Our pedagogical experience has shown that the use of this technique allows us to increase motivation, interest, level of knowledge, mental activity is activated, and applied professional skills are formed.

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