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VISUALIZATION AS A COMPONENT OF THE EDUCATIONAL PROCESS IN THE COURSE OF ANALYTICAL CHEMISTRY FOR STUDENTS OF TECHNOLOGICAL SPECIALTIES

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Abstract. Visualization of the process of learning allows, with a minimum number of classroom hours, to familiarize students with a large amount of theoretical and practical material. This article proposes a model of one teaching unit of the module: "Spectroscopic and other optical analysis methods": "Molecular absorption spectroscopy". Visibility and intelligibility of complicated material allows achieving a high level of knowledge among to-be technical engineers.

Keywords: visualization; analytical chemistry; optical analysis methods; level of knowledge; laboratory practicum

Resulting from the optimization of the educational process, being held in the context of the modernization of the present-day education, in particular by introduction of new state educational standards and programs in analytical chemistry, the time allotted for studying the discipline "Analytical Chemistry. Physical and chemical methods of analysis" for students of the Faculty of Storage and Processing Technology of Plant and Animal Raw Material is reduced. Therefore, in the process of studying the discipline special importance is given to the formation of "competence" by the method of visualization. Visualization of a module is the combination of educational and creative materials, of informativity and intelligibility. Visualization allows to represent and to structure the information, to ensure the consistency of the presentation of the information, to demonstrate the connection between a text and images that contribute to the active perception of educational materials (Stanger-Hall et al., 2011).

The main purpose of writing this article is to create a model (plan, sample) of mastering the program of studying the fundamental discipline in the face of the reduction of class hours. To achieve this goal, the following task was set: to fill each specific type of a study load with new content, to adjust teaching methods and means to the modern educational process, to improve and modernize "good old methods" (Gusseva, 2017).

Hours allotted for studying the discipline are divided between classroom and out-of-classroom studies. One half is devoted to lectures, laboratory and practical classes, and tests. The second one implies deep and detailed study of the information at home or in the library (for instance, creation of individual or group presentations, reference schemes, abstracts or lecture notes) (Fadeev et al., 2014).

The entire course "Analytical Chemistry. Physical and chemical methods of analysis" is divided into separate parts – modules. Each classroom and out-of-classroom type of activity (preparation for seminars, admission to laboratory work, work in chemistry room, presentation of laboratory work, tests, colloquia, fulfilment of individual assignments, homework, etc.) is scored according to the rating. Academic performance in each module is usually evaluated at 100 points maximum. Points for each module are summed up, and a pre-session grade is given. The final grade consists of an examination grade and a pre-session grade. Advantages of using a module study are that it comprises all the innovations that have been accumulated in theory and practice.

The teacher's role in the educational process changes dramatically. The task of a teacher is not limited to just issuing grades, but necessarily includes motivating students, development and consolidation of academic, social and personal competencies through the use of the latest educational technologies. Taking into account each student's level of development and abilities, a teacher creates a personal educational plan, guides the students' learning and cognitive activity through a module and takes adequate teaching measures to stimulate them and to correct faults discovered.

An important aspect of organizing the educational process is to find an ideal proportion between traditional and innovative approaches to education.

In the content of the course "Analytical Chemistry. Physical and chemical methods of analysis" we identified three modules: spectroscopic and other optical analysis methods; electrochemical analysis methods; methods of separation and concentration. There was laboratory-based work prepared for each module allowing to revise, to consolidate and to test lecture information in practice. Relevant laboratory practicum, as well as methodical guidelines to homework with examples of solving typical problem, is prepared.

The authors of this article offer to review the organization of one of three modules – "Spectroscopic and other optical analysis methods" (Table 1). While composing the content and forming up the module we were guided by the following didactic principles: scientific, fundamental and systematic character (Khamitova, 2011), interdisciplinary links, professional orientation, orientation of the educational process on the self-education of students, etc.

Table 1. Acquiring knowledge in the module "Spectroscopic and other optical analysis methods"

No.	Acquiring knowledge in the module "Spectroscopic and other optical analysis methods"	Assessment of knowledge
1.	Main teaching units: – molecular spectroscopy (nephelometric and turbidimetric analysis methods, infrared spectroscopy, luminescent analysis); – atomic spectroscopy (atomic absorption analysis method, atomic emission spectroscopy); – refractometric analysis method; – radiospectroscopic analysis method (nuclear magnetic resonance, electron paramagnetic resonance)	Carrying out the continuous assessment of knowledge on the theoretical information in the form of tests
2.	Development of practical skills: – to quantify the content of various objects with the use of modern physical and chemical analysis methods; – to register a signal; – to make solutions of the required concentration; – to use analytical balance	Examination of skills of operating modern equipment and knowledge of rules of operating it; Presentation of the results of laboratory work; Presentation of the results of individual assignments
3.	Acquisition of skills of performing routine calculations: – to determine the mass of the quantity of substance for analysis; – to determine the concentration and volume of solutions; – to carry out statistical processing of the results of the experiment. Guided individual students' work in the form of performance of individual tasks with the possibility of consulting with the teacher	Examination of solving problems on the topic "Spectroscopic and other optical analysis methods"; Presentation of individual tasks performed during guided individual students' work
4.	Examination of students' individual work on studying a selected topic of the module with the use of information on electronic media; Preparation of individual presentations with the use of multimedia technologies	Students' class presentation of the previously prepared information (with the use of electronic resources); Colloquium on the section "Spectroscopic and other optical analysis methods"
5.	Excursion to the analytical laboratory of the enterprise in accordance with the specialty of a student	

Main informative components were identified in the content of each teaching unit: theoretical foundations of a method, configuration of a device, analytical capabilities of a method, metrological characteristics of a method.

Then there were identified informative conceptual elements that are responsible for ties with other teaching units, academic disciplines and the student's chosen specialization.

Mastering the discipline is based in the competencies, earlier acquired by students during studying the disciplines "Physics" and "General Chemistry". The connection to the student's specialization can by analysed on the example of the work performed on the module: optical analysis methods (Table 2).

Table 2. Topics and laboratory works

Topics	Laboratory work
Photometric analysis methods	1. Cyanide photocolorimetric method for determination of reducing sugar in confectionary and semi-finished products 2. Determination of protein denaturation degree in flowur
Refractometric analysis method	1. Determination of lactose in milk and cultured milk products 2. Determination of sucrose in sweet curd products
Nephelometric and turbidimetric analysis method	1. Phototurbidimetric determination of calcium

Let us take a closer look to one teaching unit of the module: "Spectroscopic and other optical analysis methods": "Molecular absorption spectroscopy".

During the lecture the following types of visualization are used: presentation, charts, diagrams, drawn out together with the students, detailed questions and answers to them are given (Gusseva, 2017). Thus, feedback from the students can be received.

After theoretical consideration of the topic during a lection, there are group classes accompanied by practical learning of the studied information. Students familiarize themselves with the instruments, write down executed work in a work book, where textual information is entered in form of a table, flowcharts are made (indicating the main components of the instrument), measurements are entered, dependency diagrams are made, conclusions are drawn based on the topic of the work. Thus, a report of the executed work is elaborated. Such an understanding of visualization as an observation process implies student's mental and cognitive activity.

Example

Laboratory work No. 1

Topic: “Determination of Iron (III) in drinking water”

Objective: to develop skills in using a photoelectric colorimeter, to study the method of photometric determination of a substance concentration in a graphical manner (Table 3).

Table 3. Progress of work

<table>
<tr><th>Task</th><th>Observations</th><th>Calculations</th></tr>
<tr><td>1. Prepare 6 standard solutions with the content of Fe^{3+}: 0, 0,2, 0,4, 0,6, 0,8, 1 $mg/50cm^3$</td><td rowspan="5">Are the obtained solutions coloured and on what it depends? Explain</td><td rowspan="2">1. Enter obtained data in a table
<table>
<tr><th>No.</th><th>Fe^{3+}, $mg/50cm^3$</th><th>A</th></tr>
<tr><td>1.</td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td></tr>
<tr><td>5.</td><td></td><td></td></tr>
<tr><td>6.</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>2. Measure optical density of the standard solutions</td></tr>
<tr><td>3. Make a calibration graph in the following coordinates: content of Fe^{3+} – optical density of a solution</td><td>2. Make a calibration graph in Excel</td></tr>
<tr><td rowspan="2">4. Determine optical density of the analyzed water samples (3 samples)</td><td>3. Enter the measured values of optical densities in water samples in a table
<table>
<tr><th>Water samples</th><th>A</th></tr>
<tr><td>Sample 1</td><td></td></tr>
<tr><td>Sample 2</td><td></td></tr>
<tr><td>Sample 3</td><td></td></tr>
</table>
4. Calculate the content of Fe^{3+}(Q, mg/dm^3) according to a formula</td></tr>
<tr><td>5. Write down to the work book State Standard of the Republic of Belarus and compare the results obtained during the experiment with the maximal permissible concentrations of Fe^{3+}</td></tr>
</table>

Answer the following questions:

1. What analysis method was used and what is its essence?
2. What does a calibration graph reflect?
3. What determines optical density of a solution?
4. The main components of the photoelectric colorimeter.
5. Is it possible to determine the concentration of iron by using the addition method?

Laboratory work is considered to be done successfully if the results obtained by a student are within the permissible error coincides with the true value. After each laboratory work, there is a presentation of the performed work in the form of an individual interview with a teacher (a student shall answer 3 questions on the topic of the performed work). The report prepared by a student and signed by a teacher is a documents confirming successful accomplishment of the relevant works of the laboratory practicum.

After mastering a method and an instrument students are inviter to perform individual laboratory works related to their future job profile (see above).

The next step in the acquisition of materials is the current control of knowledge. Current control of knowledge is carried out after studying a topic. Of all presently known methods of control allowing to assess the students' level of knowledge, testing is considered to the most promising, and has several advantages, such as objectivity, compactness, promptness, operational efficiency. The indisputable advantage of such a control is that students will know their marks immediately after completing the task, sometimes they may see the mistakes they made. An important component in knowledge control is the principle of differentiated approach, which takes into account individual abilities of a student.

We have developed and implemented two types of tasks:

1. Tasks in the form of a test are picked up not according to the principle of ascending difficulty, but according to their level of difficulty: grades "3 – 4", "5 – 6", "7 – 8", "9 – 10". Each test task offers the same number of questions, which, however, are intended for students with different level of knowledge. It should be noted that if students' choses the level "5 – 6', he/she gets a 6 only if he answers all the questions of this level correctly; if he/she makes one mistake, he/she gets a 5. The student has the opportunity to choose the level that is the most acceptable for him on the topic.

2. In the second case, a test with 10 questions with evenly ascending difficulty is proposed. Each question is evaluated by a different number of points: Level 1: for questions from 1 to 4 – 0,5 points; Level 2: for questions forms 5 to 8 – 1 point; Level 3: for questions from 9 to 10 – 2 points. This test allows to evaluate the structure of knowledge and skills and to qualitatively measure the student's level of expertise (Kudyrko & Malyevskaya, 2008).

Analysis of the results of the test lets determine the spheres of chemical knowledge and skills of the students (Tarasova & Kolotova, 2013), as well as to identify those students who have not mastered the material and whose knowledge and skills need to be corrected, supplemented and improved. Correctional work with the students can be carried out by the teachers during extracurricular activities and consultations.

The final stage in mastering the material is the guided individual work (GIV) of a student on studying a separate topic of the module using information on electronic media. We propose to have a closer look at one of the interactive teaching methods used during studying the course.

Interactive teaching methods are widely used at all levels of the educational system. A literal translation means: "interactive methods are methods that allow learning to interact with one another", and interactive learning is learning built on interaction of all students and the teacher. These methods are the most consistent with the learner-centred approach because they involve collective learning, or learning in cooperation, and the student and the teacher are the subjects of the learning process. The teacher more often acts ad the organizer of the process of learning, the creator of the conditions for the initiative of students.

Effectiveness of the use of interactive teaching methods is indisputably, but the difficulty lies in their application in the process of teaching sciences.

One of the methods of interactive teaching is "the cooperation in cooperation" method. Students are invited to prepare material (given for GIV) using this method. For this they are divided into subgroups of 3 within the group, each of which chooses the topic to prepare. Within the subgroup each student receives a mini-topic (a specific question), on which he works later. Then the form of control is selected, for example, all the material is prepared by the students of a subgroup as a multimedia presentation, shown during the class. Thus, in a relatively short period of time, it is possible to study a lot of material. Preparing a presentation, students visualize the information and have an opportunity through the exchange of presentations among subgroups to study each proposed topic in more detail. It is important to note that there is a possibility to evaluate each student additionally on the results of his performance.

The use of interactivity in the process of study as practice shoes removes emotional stress of students, gives an opportunity to change the forms of their activities, to switch attention to the key issues of the topic. As experience has shown, the material that the students did not have time to study while preparing themselves to the exam, is now very well digested, which makes it possible to increase the final grade (Fig. 1).

As the result, the final grade for the module includes the grade for mastering practical skills; the grade for performing individual laboratory works in accordance with the specialty; the grade for test control; the grade for solving home assignments on the topic; the grade for the guided individual student work; the grade for colloquium.

The system of module and rating assessment of knowledge enhances the motivation of the students, increases their wish to improve the rating, and thus to improve their results, not only by gaining knowledge in class, but also independently (Kharina et al., 2015). Visualization accelerated and deepens the understanding of the knowledge structure of the subjects of analytical chemistry. Visualization of knowledge helps to process the information more deeply, contributes to and

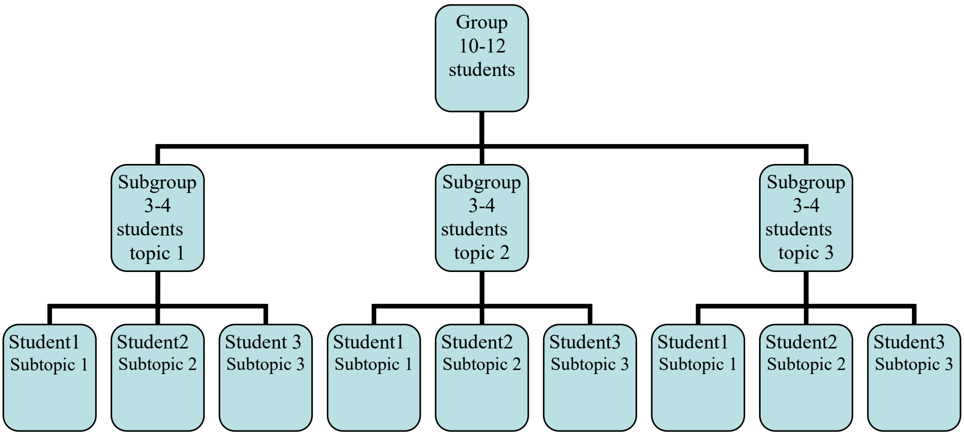

Figure 1. Construction of students' groups

improves the ability to apply knowledge in new situations, allows to link concepts from different areas of the student course (Raputa, 2018).

In conclusion we would like to say that we don't consider our teaching system to be an ideal one. We keep changing something, adding something, looking for new approaches, returning to the previous sometimes. The most important thing is to arouse the student's interest, to create for them the conditions that would contribute to his intellectual growth and full development of their personality.

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