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FORMATION OF SUBJECT COMPETENCIES IN THE LEARNING OF CHEMISTRY

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Abstract

In the article there is considered the problem of subject competencies formation as the condition for content updating of natural science education which is relevant for didactics of Chemistry. Subject teaching methods oriented at creativity, metasubject and personal results in education were updated and tested experimentally on the basis of competence approach. Chemistry teaching content modeling according to competencies as activity unites means determination of context, technology and algorithm of actions. We consider the competency as motivated sequence of actions in a certain context. The technology base for Chemistry teaching according to competencies is the set of tasks aimed at mastering and demonstrating action algorithms. As a result, the skills of observing, explaining, classifying, generalizing, identifying, forecasting, making conclusions, which are being formed during the experiment, develop and are filled with certain content and mastering of universal ways of action is provided. School practice shows that many teachers are sill aimed at transmitting of subject knowledge which mastering provides results for Unified State Exam and preparation for university entrance, but does not facilitate formation among pupils of such competencies as novelty sensitivity, cognitive initiative, choice risk, persistence in cognitive interest implementation. Therefore content, methods and technologies of teaching demand deep updating in order to eliminate out-of-date knowledge and methods. Knowledge is included into the content, and it is necessary to regard this while updating the content of natural science education.

Keywords: Teaching, competencies, content, context, algorithms, technologies.

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1. Introduction

Nowadays it is becoming obvious that a new educational reality has appeared which main characteristics are innovativeness and uncertainty. Schools have been "forced" to work in innovative projects, the number of which can be up to 15 within one educational establishment, and "the demand of innovativeness from all participants of educational process at all levels in the world educational space is beginning to evoke anxiety of scientific pedagogical community" (Ivanova, 2016). Modern pupils pay a lot of attention to personal educational results: the ability to learn, to reach their life goals themselves, to obtain important practical knowledge and skills, "skills of the 21st century" (Zhilin, 2011; Hayden, 2013; Schleicher, Ramos, 2016), the ability for self-realization and self-development. There are models of "educational achievements" (Wagner, 2008). Education oriented at transmitting ready subject knowledge, mastering of which gives high results at the Unified State Examination (USE), but doesn't facilitate deep comprehension and implementing of this knowledge contradicts education providing mastering of universal ways of activity, achievement of creative and personal results in education. Meanwhile it should be noted, that works of comparative character are published in a small amount, but there are interesting researches in this field in them (Lavonen, Sothayapetch & Juuti, 2013).

During the press-conference the Minister of education and science of RF O.Yu. Vasilyeva revealed the nearest future plans on changing of system of education in Russia. She said that "the USE will not be cancelled because it a powerful social lift which allows children from Siberia, the Far East to enter the best higher educational institutions of the country". The Minister called for comparing the statistics in accordance with which today in capital higher educational institutions there study about 65% of students from regions, and 35% are Muscovites, but before the USE the situation was quite opposite. In practice many teachers are still aimed at transmitting of subject knowledge, mastering of which provides good results of the USE and preparation for entering higher educational institutions. General implementation of the USE and also aging of the staff taking part in drafting tasks of the USE inevitably lead to formality of pupils' knowledge, when they learn by heart chemical reactions equations which are given in corresponding literature and on the site of Federal Institute of Pedagogical Measurement. According to the words of MSU rector V.A. Sadovnichy such tasks check "if a pupil is able to keep in memory a big amount of crammed information". There was formed a "tutorial" model of subject education expensive for parents when preparation for the USE prevails that generates low pupils' motivation due to lesson monotony. Practical implementation of such a model is possible only in cities where there are tutors. For rural pupils "tutorials" may be simply unavailable. Besides, the cult of uniformity always restrains the development of gifted pupils.

2. Problem Statement

Statement and investigation of the problem concerning new content modeling of general education through formation of subject competencies are now not so much in the area of subject didactics as at the state level. In the President of Russia V.V. Putin's Message to the RF Federal Assembly on December 1, 2016 it is said: "It is necessary to develop actively creativity at school, schoolchildren must learn to think independently, to work individually and in the team, to solve original problems, to set goals and to achieve them so that in future it will become the basis for the successful and interesting life".

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A relevant problem of contemporary researches in the field of subject didactics is the formation of such pupils' competencies as responsiveness to innovations, cognitive initiative, risk of choice, persistence in realization of cognitive interest. In conditions of catastrophic increase of information methods of its compaction are necessary. Therefore, teaching content, methods and technologies demand deep updating to eliminate out-of-date knowledge and methods. How can one investigate this problem in the frame of subject teaching prevailing nowadays? How can one build education via discovery?

At the International conference "Results of international researches TIMSS and PISA in 2015 and factors influencing changes in the system of education" (February 1, 2017, Moscow) they said that Russian schoolchildren are weak at scientific knowledge comprehension and especially its implementation. Skills to observe, to explain, to generalize, to recognize, to forecast, to make conclusions which are formed via the experiment, practically have not been formed in them. The secondary school-leaver must be able to produce ways for the solutions of global problems which the humanity faces: ecological, energetic, concerning raw materials, and the role of chemistry in the process of these problems solution (Lavonen, Sothayapetch & Juuti, 2013; UNESCO, 2012). Radical changes in teaching methods are necessary – the transition from methods oriented at only mastering subject knowledge to creation of methodical systems providing mastering universal ways of activity, achievement of creative and personal educational results (Ivanova & Serikov, 2017).

3. Research Questions

In the terms of sharp decrease of number of classes given for the studying of subjects from educational field "Natural Science" Chemistry teachers have serious difficulties in realization of demands of Federal State Educational Standard for Secondary Education (FSES SE), especially it concerns the chemical experiment as a part of education content. Didactic functions of the chemical experiment involving laboratory tests and practical work given in Chemistry textbooks with rather big content have decreased. In Chemistry methods of teaching the chemical experiment is one of the main methods. In the system of forms combining words and visualization known in Chemistry methods of teaching the experiment has always taken a leading place. However practical usage of the experiment is often limited by using it as the means of knowledge illustration and practical skills improvement. At a less degree the experiment is used as a source of knowledge about properties of substances and the method of world perception. Absence of experimental tasks in USE is considered by teachers to be one of the reasons for this.

The problem under research connected with updating of content and methods of teaching Chemistry in contemporary conditions needs to be recast from the principally new philosophical point of view. In the terms of implementation of competency approach Chemistry teaching at secondary educational institutions supposes the formation among pupils:

• systematic Chemistry knowledge creating the basis for continuing education and self-education at all stages of training and future professional activity;

• socially important value orientations including general cultural and personal development of pupils, perception of the value of gained Chemistry education, feelings of responsibility and patriotism, social mobility and the ability to adapt in different life situations;

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• key general and subject competencies (knowledge, skills, ways and experience of activity regarding specific features of Chemistry as fundamental natural science) providing achievements of subject and metasubject results of education.

As the response to demands of the modern society there appeared new kinds of activity such as training-research, and in connection with the demands of FSES new forms of lessons – lessons-investigations have received a special role. Thus there are formed experimental and intellectual skills of experiment planning and modeling, its results forecasting and interpreting, hypothesis constructing and checking, etc. (Volkova, 2016).

As an example we will present a scenario of the lesson-investigation which was conducted by us in the secondary school № 18 in Kaluga in the form with profound studies of Chemistry.

The lesson-investigation (Gerus & Kuznetsova, 2004): the practical class in the 9th grade with profound studies of Chemistry devoted to the theme "Construction of the substance solubility curve according to experiment data" (Akhmetov, 1988) takes two academic hours.

The aim of investigation:

• to define solubility of the given salt at different temperatures (pupils work in groups of 3-4 people, for each group there are given special tasks, for example, to define solubility of calcium chlorite at the following temperatures: 20, 40, 60 degrees C); they define solubility of the same salt at different temperatures;

• to construct the curve of salt solubility depending on temperature;

• to interpret the results of the research comparing the curve the given salt solubility with other salt solubility curves made by other research groups and also with the solubility curve of the same salt given in the textbook;

• to formulate the regularity reflecting dependence of hard substances solubility from temperature.

Work algorithm (Gerus & Kuznetsova, 2004).

1. Weigh the porcelain cup
2. In the flask heat 40-50 ml of water till the temperature of 1-2 degrees C higher than the specified one
3. Make the saturated solution at this temperature. In order to do it add the salt in small portions in water while stirring with a glass stick until a new portion of the salt is not able to be dissolved.
4. Measure the temperature of the gained saturated solution. Pour about 25 ml of the solution into the earlier weighed cup. The cup with the solution should be weighed. Then evaporate the solution. Be careful that the solution doesn't boil and splash (regulate the fire of the burner while heating).
5. The cup with the salt evaporated from the solution should be cooled and then weighed.
6. Measure mass of the salt and the evaporated water. Calculate the solubility of the salt at the given temperature.

At the next stage of the lesson pupils construct the salt solubility curve at the given temperature. Here the skill of interpreting results of the experiment in graphs is formed.

Construction algorithm of the salt solubility curve at the given temperature (Gerus & Kuznetsova, 2004):

1. At X-axis put temperature values measured by all pupils (4 values).

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2. At Y-axis put values of the given salt solubility (g/100 g of water) at given temperatures.

3. Connect given points with a smooth curve.

4. Compare the solubility curve of the given salt with solubility curves got for other salts by other research groups.

5. Compare the gained solubility curve of the given salt with the solubility curve for the same salt shown in the textbook.

Summarizing of the lesson is made, group results are fixed and compared, conclusions are made.

While discussing the course of the ivestigation it is important to emphasize the attention on the fact if the given regularity is always true, if there are examples not proving the conclusions made. At home pupils can be offered to make the analysis of the relevant literature and to find examples of mysterious natural phenomena connected with the process of solubility, for instance why some pore solutions which are located in small pores of the Earth entrails don’t freeze up to -70 degrees C.

We know that fulfillment of this task will take additional time when the teacher can combine the lesson with extra-curricular forms in the frames of additional education. Thus during the lesson one can built several “individual educational routes” (Ivanova & Serikov, (2017) for pupils with different educational abilities. It is important to dose educational load that leads to the increase of the part of independent work during the fulfillment of the task.

4. Purpose of the Study

The main aim of research: to investigate the effectiveness of the system of subject competencies formation as the renovating condition of general chemical education content and methods of teaching; to update and experimentally to test methods of subject teaching oriented at the provision of mastering universal ways of activity, formation of subject competencies, pupils’ achievement of creative and personal results regarding the demands of FSES to the formation of pupils’ skills to learn the world actively.

5. Research Methods

In the course of research the following methods were used: the analysis of didactic and methodical literature and school practice with regards of world tendencies of education development; comparative analysis of pedagogical experience of application of traditional approach aimed at knowledge and competency approach in Chemistry teaching; the experimental test of the developed methods of teaching in the terms of contemporary school information environment.

Comparative analysis shows that in the frames of the traditional approach the main content of education means mastering of the theme or a part of the programme. Subject teaching is aimed at mastering of the theme in the subject field the boundaries of which are not defined and can change. The result of the theme teaching is knowledge of the theme content. Competency approach in teaching contradicts the traditional knowledge-oriented theme teaching, as it is considered to be the concept of teaching competencies or practical skills, that is, competency is considered to be the content of education. The competency acts as the unit of the content and activity. The structure and the content of the competency as the unit of activity may be represented as the triad: motivation → context → technologies and algorithms. Such model of education is used in our country only at the higher educational institution or post-graduate

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stages of education. The main content of competency teaching is defining of the context and the algorithm of actions. The basis for the technology of competency teaching is made up by tasks aimed at mastering and demonstrating of action algorithms. Thus, the competency as a unit of activity is defined as motivated sequence of actions in a certain context (Schleicher & Ramos, 2016).

The general feature of implementation of both traditional and competency approaches is the context. For example, it is very important to include into the content of Natural Science education the materials of contemporary Natural Sciences researches connected with successes, problems and troubles of the contemporary society, results of achievements in the fields of science and technology, and also new questions, new problems of interscience character. Knowledge is sealed in the context and it is necessary to regard it while updating the content of Natural Science education (Carnoy, Khavenson, Loyalka, Schmidt & Zakharov, 2016; Wagner, 2008).

6. Findings

The important component of education content is calculation and qualitative problems.

FSES defines finding chemical formulae of organic substances and making chemical reaction equations reflecting their properties as one of subject competencies. In order to form it, it is necessary to build the context logics of such tasks and define corresponding algorithms and technologies. For example, having only one Chemistry class a week in the 10th grade one must teach to solve problems concerning the finding the molecular formula of the substance according to the data about its composition: in accordance with weight fraction of each element and its density or relative density to another gas; in accordance with masses and volumes of combustion products. Besides, among the USE tasks there are problems on application of the substance mass conservation law, knowledge of acid and base theory in order to build the structural formula of the required substance. Let's give examples of such tasks.

Problem 1. According to the analysis the substance contains 48.649% of carbon, 43.243% of oxygen and 8.108% of hydrogen. How many esters does such composition have? Make structural formulae of all isomers of this composition and name them (Khimiya, 2013).

Problem 2. The organic substance has relative density of vapors 46 in accordance with hydrogen. The sample of this substance with mass 13.8 g was burnt and got carbon monoxide (IV) in volume of 23.52 l (at normal conditions) and water with mass of 10.8 ml. Define the structural formula of this substance.

Problem 3. Some organic substance A interacts with sodium hydroxide. Sodium weight fraction in the product of this reaction is 33.82%. The substance A is known to interact with magnesium oxide, ethanol and give rose color to litmus. Define the molecular formula of the substance A. Make up the chemical reaction equation of the substance A with magnesium oxide.

Problem 4. Maximum monobasic carboxylic acid with mass of 6 g completely reacts with the same mass of maximum monatomic alcohol, and there is 10.2 g of reaction product. Define the formula of the acid.

Algorithms of problem solutions:

1. Defining of the formula according to the known element composition:

• define the quantitative composition of the substance;

• define the simplest indexes;

• make up the empirical (simplest) formula of the substance;

• calculate molar mass of the substance;

• define the true formula of the substance.

2. Defining of the substance formula according to the combustion products:

• define quantitative composition of the substance, for this calculate the quantity of the substance and mass of each element including into the substance composition;

• calculate molar mass of the substance;

• make up the empirical (simplest) formula of the substance;

• make up the structural formula of the substance;

• write down the chemical reaction equation where this substance takes part.

3. Defining of the substance formula according to the known general formula and weight fracture of one of elements:

• make up the general substance formula of the given class;

• define the index value n in the general formula.

4. Defining of the substance formula according to its reaction property:

• make up the general substance formula of the given class;

• make necessary calculations with the help of chemical reaction equations.

We recommend solving complex problems the context of which supposes the defining of the organic substance formula in accordance with the data about its composition, establishing its structure, making calculations with the help of chemical reaction equations.

Problem 5. Solid carbohydrate A and liquid carbohydrate B have one and the same empirical formula and contain 92.3% of carbon in mass. The solution A in B doesn't decolorize bromine water. While interacting of 52.0 g of this solution with acidulous solution of potassium permanganate there was formed a single organic product – benzoic acid to naturalize which 72.1 ml of 10% of sodium hydroxide ($\rho = 1.11$ g/ml) was necessary. Identify the structure of substances A and B and find the weight fracture of A in the solution

Our long experience of school practice shows that the analysis and the solution of such problems allow individualizing teaching, developing cognitive interest and creative abilities of pupils (Volkova, 2017).

7. Conclusion

The made research can be characterized as theoretical-experimental with marked practical orientation. The results of the research confirmed the hypothesis about the opportunity of achievements of general education aim which consists of revealing of pupils' abilities and intentions and their gaining systematic experience in the process of mastering pedagogically adapted languages of native and world culture for personal including professional self-determination, self-realization and creative development in the terms of post-industrial epoch and "infonoosphere" civilization (Volkova, 2016). To achieve these aims it is necessary to equip pupils with fundamental knowledge of basic development laws of evolution, society and science which is the basis on which one can build any further continuously changing knowledge (Blaschke, 2012).

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There was investigated the effectiveness of methodical system for formation of subject competencies as the condition of updating of content and methods of Chemistry teaching. It was established that in order to achieve the set aims one should search for reserves and methodical resources in the subject content itself. There were updated and experimentally tested methods of Chemistry teaching oriented at the provision of mastering universal ways of activity, formation of subject competencies. The process of teaching must be built in accordance with "natural way of cognition". At the same time it is necessary to emphasize mastering the content connected with pupils' personal observation, with the results of their perception, systematization and comprehension, and also modeling permitting building models and "seeing' objects of environment. Modeling of new content of Chemistry education and methods of teaching becomes an important didactic function of competency approach.

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