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The Ideas of Constructivism and the Process of Evaluation of the Scientific Literacy of Students during the Process of Their Education in Chemistry

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Abstract

The article studies the principles of constructivism which are directed towards the education in chemistry and presents my shared experience of their introduction in the pedagogical practice through an activity-oriented approach of the knowledge acquired by *Free Energy* club. Project-based work in small groups and the realization of a students' representative event creates opportunities to broaden the scientific literacy in natural sciences, provokes the students' research abilities, oriented towards the formation of technical and applied practical knowledge, skills and competencies. The article shares methodological solutions of the integration between theory and practical work during the integration of students and their parents towards the process of evaluation and self-evaluation. It creates suitable circumstances for the students to gain real perspective of the level of their knowledge and skills, as well as to compare themselves with the other participants. Using all the knowledge and skills which the students have acquired by various scientific areas, they form inter-subject and inter-disciplinary relations and links.

Key words: constructivism, teamwork, evaluation and assessment criteria and indicators, self-evaluation and self-assessment

Researches of education and the work market show a decrease in the interest of young people towards natural, technical and engineer sciences. The adolescents tend to make fewer efforts to develop their intellectual potential in these spheres.

One opportunity for the modern education in natural sciences is to turn towards the philosophy of constructivism, which places the learner in the center of the educational process. This pedagogical conception emphasizes that learners change their thinking in order to include new models, raised by information gained through personal experience or adaptation of different interpretations of the experience shared by their environment. The social contact is an important advantage which is inherent to constructivism. Its fundamental principles can be formulated the following way:

- The learner searches models which he should construct himself provoked and motivated by the educational environment.
- The construction of meanings requires understanding and in-depth study of details, which construct summarized models of phenomena and processes in their interrelation.
- The teacher selects, organizes and guides the activities which ensure the process of thinking and perception of the world in its natural logical interrelation and comprehensiveness.
- The evaluation measures "the individual increase" or "the added value" of this process, considering the level of generalization of the model, its application in real situations. [1]

The activity-oriented approach is inherent to constructivism and it provides the learners a work environment where they can build their own knowledge, skills and competencies, based on personal experience and interaction with the surrounding reality. This approach highlights not only the cognitive and emotional abilities of each learner, but also the whole specter of abilities which the learner possesses and uses in a social environment. [2]

"We remember only just 20% of what we hear, 30% of all we see, 80% of the things we formulate ourselves and 90% of what we do ourselves." (Gudjons, 2003:50)

The application of activity-oriented approach reveals some positive aspects:

- Learners are engaged in the educational process by performing purposeful actions which create products with practical application;
- Learners perceive the information through all senses, thus achieving an active stimulation of various types of intelligence;
- Learners are placed in situations, provoking their creativity, teaching them loyalty, tolerance and responsibility;
- Learners create interdisciplinary bonds which use knowledge and skills acquired in all scientific areas they have studied;

- The inter-subject bonds upgrade knowledge and skills and achieve horizontal and vertical integration of the newly-formed competencies. [2]

One of the possibilities to guarantee an active working environment is the involvement of learners in extracurricular activities in various projects. In the pursuit of the teacher to respond to the general aims he needs to experiment during the realization of the implementation of the conventional and interactive, innovative methods and forms in his teaching practice.[3] In chemistry education the activity-oriented approach suggests the application of modern information-communication technologies which ensures the creation and application of creative and motivating pedagogical materials, breakdown of stereotypes when providing opportunities to engage students according to their abilities and studying needs. However, the wish of students to actively participate in the educational process may be fulfilled only in case they accept the aims set by the teacher as their own, personally significant, corresponding to their interests. [4]

The extra-curricular education in Chemistry and environmental protection have been traditionally held at the 'Vasil Drumev" High School of Mathematics and Natural Sciences. At present, these activities are held in:

1. groups for education of students who demonstrate avid interest to natural sciences. They aim at their preparation for participation in national competitions and Olympiads in Chemistry and they are provided for by the "With Care for Every Student" National Program of the Ministry of Education and Science,
2. school for extra-curricular education in Chemistry sponsored by the American Foundation for Bulgaria,
3. 'Mendeleev' and 'Free Energy' clubs in accordance to project BG051PO001-4.2.05 - "Development of Human Resources" programme.

The major aims of the extra-curricular groups are:

- to ensure communication in an informal environment which will allow extensive acquaintance between the teacher and the students;
- to optimize the selected teaching methods, forms and resources which will ensure a higher level of readiness to participate and engagement in the activities;
- to construct summarized models of natural phenomena and chemical processes in their interrelation and dependence which will guarantee a higher level of scientific literacy of students;
- to enhance the motivation of students to participate in the educational process by joining them in various extra-curricular forms;
- to ensure succession between the groups for additional work and the newly-enrolled students;
- to direct students to display their personal achievements.

Observing the volunteer principle of the extra-curricular activities, two clubs were organized during the academic 2014 – 2015 year, namely 'Mendeleev club' and 'Free Energy club'. The activities ensured the students 'engagement during out-of-school periods, including the winter holiday. According to the age-specific features and future plans for professional realization, the teacher has prepared a selection of topics, corresponding to the underlying goals of the project-based education, the students' interests and the possibilities for co-operative work. The planned topics were mainly oriented to applied practical work through the application of a chemistry experiment as a method of studying which proved to influence the students' cognitive and emotional areas of personality. Furthermore, we used informative methods of studying such as counseling, discussions, problem-based lectures; research methods with educational purpose: research of literature sources, including the Internet, the formulation of a working hypothesis and the planning of a laboratory chemical experiment, creation of logical charts, visualization of trial data and results in tables and charts; product-practical methods: creation of 3-D models of molecules and crystals by the computer programme ACDLABS 11.0, formulation of algorithmic models for balancing chemical equations with complex oxidation and reduction processes, etc.

During our work, the students prepared and realized a public appearance which stimulated their initiative and their ability to work in small groups while they prepared and performed to an audience their projects on the following topics: "Occurrence of water", "Construction and characteristics of water", "Water – the main factor of climate on earth", "The water and life on earth", "The water and the contemporary ecological issues for the humankind", "Natural waters – a resource for sustainable development". During the preparation stage seven teams each consisting of five students were formed and their tasks were guided by the common task: to prepare and perform an informative product and to perform laboratory tests, applying their technical, practical and communicative skills using the specific chemical terminology, scientific style and the contemporary information technologies and to

present the level of their scientific literacy in the area of natural sciences.
During the preparatory phase the teacher plays the role of a consultant, while students independently work on their tasks to research various sources of information, make up demonstrative materials, select chemical experiments. During this stage the students were informed about the requirements to the visual and informative products they were creating /Table 1/. This made possible the self-monitoring and self-assessment of their individual and team work.

Table 1

Criteria	Indexes
1. Selection of appropriate information and chemical experiments	scientific authenticity; technical authenticity; actuality; applicability.
2. Scientific style	correspondence between the generally accepted scientific and the used by the students terminology; correct spelling and suitable vocabulary; correct use of chemical symbols; precision of the technical laboratory operations during the chemical experiment performance;
3. General presentation of the project	correspondence between the displayed images with the visually presented information; original and arresting delivery of the topic; laboratory work safety measures observation; aesthetic presentation.

Teamwork activities created an active study environment and ensured improved communication during the problem-discussion and task-distribution, ability to give unanimous decisions, productivity in order to achieve a common goal. Meanwhile, under their teamwork studying, the students started to analyze their weak and strong sides themselves.
During the performance phase each team prepares and presents to the audience:

- A multimedia presentation on the specific topic;
- A previously planned chemical experiment with a description of the ongoing processes;

Officials and guests were invited and attended the performance. Each guest was given “a feedback paper” where they expressed their opinion. Thus the audience was actively involved and participated in the assessment according to the stated criteria. /Table 2/.

Table 2

Criteria	Indexes
1.Presentation of the information in electronic form – multimedia presentation:	Correct and authentic scientific information; Correct chemical symbol expression; Correspondence between the verbal information and the demonstrative materials (images).
2.Explanation of the experimental setting:	Precision and correspondence between the used terms and notions; Correct application and use of chemical symbols; Authenticity of the explanation.
3. Experimental technique:	Experiments - topic of presentation relevance; Organization of the experimental setting and precision during the execution of the practical operations; Observation and application of laboratory work safety measures.

During the conclusive phase the participants fill in the same “feedback paper”. Each team assesses the presentation of the other teams. During the self-assessment, the participants comment aloud their own presentations according to the selected criteria and indexes /Table 2/. The students made an analysis of the mistakes made, difficulties and problems, arisen during the preparation and realization of the ideas and decision-making phases, the organization and the performance as a whole. After

having processed the received information, the teacher makes an analysis of the performance, mentions the names of the students who performed excellently and comments on each element of the whole performance.

The realization of the performance activity achieves:

- formation of skills for: searching and assessing a specific information resource according to defined criteria, processing of information and directing it in order to achieve a specific aim [3];
- development of verbal communication – selection of information, acquisition of scientific terms, use of appropriate style and terminology, accurate chemical symbol writing, ability to contact and control the audience.
- overcoming the embarrassment resulting from insufficient experience in laboratory work, gaining confidence in their own abilities and skills;
- developing the students' idea of the process of assessment and self-assessment, introduction to specific criteria and indexes which eventually form the mark in the educational process.

The analysis shows that all the participants have enhanced their cognitive and emotional activity and engagement. Another significant conclusion of the results is the self-criticism of the participants themselves and their stated readiness to correct the mistakes, to do further practice to improve and refine their overall performance. Thus, the activity-oriented approach to the education in chemistry contributed to positive attitude, positive motivation and enthusiasm for an active implementation of the cognitive, creative and personal abilities of each of the participants.

In conclusion, when students and their teacher perform activities which have a practical result, we have the conditions which guarantee modern methods and techniques of the pedagogical influence and their combination with some contemporary information and communication technologies which provoke the thinking and activity of the student. We achieve a significant development of the scientific approach and ideology; we build an active civil stand and personal value system, related to the contemporary socially important and universal problems and challenges.

Reference

[1] Constructivist Learning Design: http://www.prainbow.com/cld/cldp.html (09.07.2013)
[2] Gudjons, H. 2003: Handlungsorientiert lehren und lernen. 6. Auflage. Bad Heilbrunn: Julius Klinkhardt.; http://www.herbertgudjons.de/buch-gruppenunterricht.php (17.10.2014)
[3] Kirova, M. 2011. Bulgarian Journal of Science and Education Policy (BJSEP), Volume 6, Number 2, 2012
[4] Gudjons H. 2007 Neue Unterrichtskultur - veränderte Lehrerrolle. Bad Heilbrunn: Julius Klinkhardt.; http://www.klinkhardt.de/verlagsprogramm/1457.html (05.08.2015)