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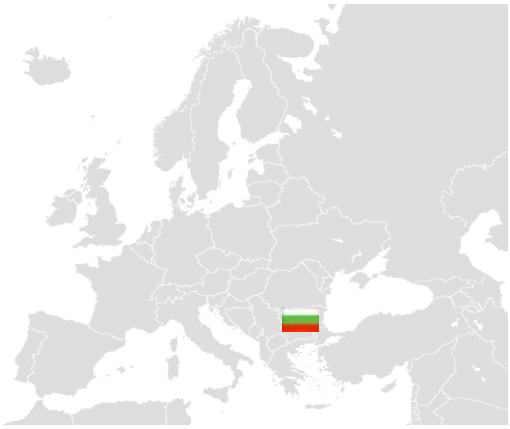
Successful Experiences in Chemistry Teaching in Bulgaria



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Successful Experiences in Chemistry Teaching in Bulgaria

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Abstract

The report presents successful experience and good pedagogic practices in teaching chemistry at Bulgarian secondary schools in the context of the European educational policy for development of key competences for the young people. Problem-based approach, experimental work, project-based activities and other new teaching methods and technologies are discussed as effective way to improve the students' scientific literacy and their motivation to study chemistry. Good practices in Implementation of information and communication technologies in educational process using multimedia presentation, videolessons, interactive materials and other are described. The report pays attention on the ways of sharing successful experience and practice in science and mainly Chemistry teaching at Bulgarian schools – conferences and forums, journals and, websites and portals.

The impact of Chemistry is all around Network Project on Successful Experiences including networking activity and testing of interactive teaching resources is described.

1 Popularization of good teaching practices in Bulgaria

As an institution in charge with the organization and implementation of the educational process at a national level, the Ministry of education and science (MES) works on the research and popularization of the good teaching practices in all spheres of education, including science. Bulgarian universities, providing education of teachers, including chemistry teachers, offer also ways to exchange pedagogical experience in teaching Chemistry**.**

1.1 Conferences and forums

The most significant forum for exchange of professional experience and good teaching practices in chemistry education is *the National Conference of Chemistry Teachers*, which takes place every two years thanks to the joint efforts of MES, Sofia university „St. Kliment Ohridski" and the Union of Chemists in Bulgaria. Apart from chemistry teachers from across the country, it involves university professors and experts from institutions in charge with the national policy on science and chemistry education. In 2013 the conference was held for 45th time with the active participation and as a part of the activities under the project Chemistry is all around Network. More than 120 teachers presented good practices and problems within conference thematic sessions „Scientific literacy and chemistry education in secondary school" and „Topical problems and European perspectives of chemistry education in secondary school and university" as:

- Reflective practices for empowerment of learning
- Using the results of modern scientific research in chemical education
- role of the research approach in science education
- The The role of Teamwork and competition-lesson
- Application of multimedia products and software *as Envision,* Chemgeneration Lab, Video lessons in the electronic platform Ucha.se etc., in chemistry education, as an approach for modern chemistry education in Bulgaria and way to stimulate students' interest in chemical experiments
- Improving of secondary students' scientific literacy through e-learning
- School scientific projects and Science on stage European festival as instruments to develop scientific knowledge
- Application of ICT in chemistry education trough the viewpoint of chemistry teachers;

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- School partnerships, informal club and after-school activities as a pedagogical approach to increase the interest in natural sciences and efficient instrument for development of scientific literacy.

Teachers discussed with experts from MES how these practices and the results from them could be applied in the new State educational requirements and Programmes of study in Chemistry and environment protection school subject.

International Conference on Training Issues of Chemistry Teachers (26th June 2013, Gabrovo, Bulgaria). The conference was organized by Technical University of Gabrovo in close collaboration with Research Laboratory on Chemistry Education and History and Philosophy of Chemistry – Faculty of chemistry and pharmacy, Sofia University, and Aprilov National High School – Gabrovo, under the Chemistry is all around Network Project. The conference aimed to turn into a forum of discussing the methods of teaching chemistry at school, competences of chemistry teachers in using ICT for enhancing students' interest towards Chemistry lessons, opportunities for experimenting different approaches and methods for teaching and learning Chemistry, ways for implementation of the most recent findings in the field of chemistry science and chemistry teaching. The 3th thematic area was dedicated to the methodology, modern approaches and good practices in teaching specific Chemistry topics –incorporation of science in the Chemistry teaching/learning process using ICTs applications as video-lessons, simple and amusing experiments, "scientific toys"; different forms of team work as school scientific projects, club activity etc. All conference papers were collected and full length published in Conference Proceedings and as PDF on Conference website [1].

Another opportunity for exchange of successful experience and good practice in teaching chemistry at school is *Autumnal scientific-educational forum* organized by the Department for information and teachers' qualification of Sofia University. Thematic area covered by the two editions of the event is directed to the teacher's competence and to the need of continuous development of new ones. Since 2011 the forum has became annual and allows Bulgarian teachers and University professors sharing experience and good practice in school education. Papers presented during the forum are full length online accessible by electronic journal „Lifelong education", published on the Department's Portal [2].

Beside the national conferences opportunity for exchange of successful professional experience give the international conferences abroad also. During the *International Conference on Suxessful Experiences and Good Practices in Chemistry Education* in Braganca (Portugal) the experience in application of ICTs based products in chemistry classes at Bulgarian secondary schools was presented [3-5].

1.2 Scientific journals and other printed editions

Az Buki National Publishing House for Education and Science of MES publishes the only national weekly newspaper on education and science *"Az Buki"* and nine science journals, each of them presents successful educational practice including in chemistry education among large number of students, teachers and experts - as it is mentioned on the publisher's official website, potential readers **o**f the journals are about "19 600 people employed in the system of education, about 615 600 students in more than 2090 high schools, approximately 47200 teachers and principals, 21,100 people encompassed at University faculty institutions of higher and special education [6].

Chemistry: Bulgarian journal of science education. The goals announced on the journal's webpage closely relate to present education policy in natural sciences and chemistry: "This journal provides a room for sharing and discussing ideas, news and results about new ways of teaching as well as of presenting new experimental and theoretical aspects of chemical science. "Among the goals of the journal is to bridge the gaps between the educational research and the school practice. All educational levels - from the early science education, secondary education, vocational education to the tertiary education and the lifelong education, are on the focus. Enhancing the interest of students by combining multidisciplinary approaches amalgamating the science with its fundament - history and philosophy of science, is persistently pursued by the journal" [7]. The journal offers large number of thematic areas for publishing and sharing of experience: Education - Theory and Practice; New Approaches; Teaching Efficiency; Teaching Experiment in Science; Advanced Science etc. The articles appearing in this journal are indexed and abstracted in Chemical abstracts and SCOPUS. *Educational Journal "Strategies of the Educational and Scientific Policy".* The

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journal aims to orient the pedagogical body from all educational system levels for applying innovative educational practices and their relation with the scientific policy of Bulgarian MES. The topic of the magazine for 2013 is dedicated to estimation in school education - the lack of appropriate methods and tools for evaluation in school system so that not only theoretical knowledge is properly assessed, but also the obtained practical knowledge remains one of the most significant problems of the educational system. The magazine publishes not only analysis of international and Bulgarian scientific researches in the sphere of school evaluation, data from international benchmarking concerning Bulgarian students (Program for international student assessment – PISA, European survey on language competence – ESLC, Teaching and learning international survey – TALIS and others) but also a special section for ideas from the practice, suggestions and feedbacks on the assessment [8].

*Educational Journal **"Pedagogy"*** is theoretical and methodological journal, which combine knowledge and information on all areas of education at all educational levels - from pre-school education to learning through life. Main topics of the journal are Philosophy of Education, Theory and Experience, Good Educational Practices, Research, Foreign Educational Tradition and Contemporary Experience etc., so the journal allows sharing of innovative ideas, insights and research achievements and good teaching practices among wide number of teachers, researchers and pedagogical experts [9].

Electronic journal „Lifelong education" It is published by the Department for information and teacher qualification and for 10 years now through its column „Good pedagogical practices" it has been providing teachers with the opportunity to discuss problems and share ideas while searching for approaches to qualified and sustainable secondary education. The journal publishes the full text of reports from the Annual Autumn Scientific and Educational Forums, organized by the Department [10].

In 2013 the Ministry organized a number of workshops in schools across the country under the motto: „School – student's desired territory". At these seminars, teachers had the opportunity to present their experience in the interactive teaching, estracurricular and club activities and all activities which contribute to the increase of attractiveness of students' education and motivation. Best practices were presented in a *Digest with good practices for interactive education* [11]. The three sections of the digest, „Didactic and innovative methods and technologies", „Self management, extracurricular and club activity" and „Limitation of dropout and incentives for school attendance" present professional searches of teachers in three major for the teaching practice directions: use of ICT in the education process; club activity, extracurricular activities and work on projects as a means of stimulating the personal expression of students; creation of more and more attractive opportunities for expression,

stimulation of participation in the educational process through individual approach to every student as a way to prevent dropouts.

1.3 Websites and portals

There are also web-based forms offering platform for sharing successful teaching experience. The most important of them are:

- National education portal, developed by the MES as a step to implement the e-learning as educational practice in Bulgarian schools [12];
- Teacher.bg or National network of innovative teachers, supported by MICROSOFT Bulgaria - the portal aims to improve the teachers' qualification and skill in implementation of ICTs in educational process and also to share the best examples of teaching practice in their applicaton at school [13].

2 Key competences and their development in chemistry education

The intensive development of technologies and processes of globalization position education as a determining factor for the building of knowing, enterprising and innovative young people with skills for adjustment and professional development. This leads to the need of application of new methods and technologies in the teaching practice aimed at the development of skills and competence for the young people to deal in a competitive environment. The most important of them are united in several groups, defined as key ones and can be found in *The European Qualifications Framework* [14,15]. The competence

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approach dominates as an efficient instrument – it offers large possibilities for personal development and practical implementation of the trainees and is preferable to the conventional approach for the accumulation of knowledge among students through offering the knowledge in the form of finished information.
In the field of natural sciences which form a knowledge of phenomena and processes, the development of key competence is part of a common process of cultivation of natural science literacy among students which in recent years follows a negative tendency of continuous deterioration. The education in physics, chemistry and biology offers a number of opportunities for its forming through:

- solving tasks and problems in real context (context-based real-life problems);
- experimental work through „doing“ (hands-on activities);
- project-based learning,
- inquiry-based learning;
- extracurricular and club activities;
- competitions, olympiads etc.

Development of competency and natural science literacy is a long process in which teachers play the main role – they have to provide conditions for its effective implementation through innovative approaches. Being an experimental science, chemistry gives exceptional opportunities for development of key competences among students which are grounds for the deveopment of other useful for their porfessional realization skills. According to A. Tafrova [16], these opportunities have to be searched for in work with natural objects (observations, assumptions, searching for proofs, conclusions), transfer of information from graphic to verbal phorm and vice versa, search, selection and presentation of information on certain topic, work with graphs, charts, diagrams, application of knowledge on unknown objects (i.e., physical and chemical knowledge on biological objects), formation of communication skills to present and solve problems, comprehension of text (abilities to comprehend and use written text and ability to use characters for practical purposes, the so called functional literacy), calculation of values of unknown parameters in a formula, device measurements (precise measurement, proper recording of results, incl. units, construction of experimental setup, closely following the instructions, resourcefullness and dexterity).
Solving real scientific problems is an approach which stimulates students to search for and find problems, to lay down questions and suggest ways to solve threm, to analyze strengths and weaknesses of each of them and make reasoned choice [17]. According to chemistry teachers ignoring the scientific research approach in natural sciences leads to rote memorization without any possibility of application in everyday life. This in turn leads to students' low motivation and lack of their interest in natural sciences.
Experimental work is another important approach for developing skills and enriching the scientific literacy. Teachers who have the ambition to develop and apply the active teaching in the training process through problem-based learning, research approach, studying through discovering and making and other ways for developing key skills, appreciate its role as an extremely efficient tool in their chemistry teaching practice.
Irrespective of which of the two elements of chemistry education at school are concerned – theoretical lessons or laboratory experiments, teacher faces one major problem: *how to engage the attention of students, to make the lesson more interesting andmore easily understandable, to convince students of the usefullness and applicability of chemistry in everyday life and to motivate them to study.* Solving of that problem is a complicated task which challenges the whole teacher’s potential – scientific, creative, pedagogical, technological. In days of technological development some of the conventional teaching methods and pedagogical approaches seem to be not efficient. Textbooks and notebooks officially approved by the Ministry do not provide serious help as they are often theoretical and the matter is presented in alien for the young people language.
Efforts of teachers and experts to overcome this disadvantage of chemistry education are implemented in several main directions. *Use of contemporary ICT* in the learning process is the one of them. For example the use of interactive mulimedia allows the visualization of chemical content – substances, chemical reactions and related definitions, quantitative and qualitative measurements etc. The interactve multimedia presentation could be successfully developed for one lesson or for group of thematically close lessons [18].
In modern pedagogical practice a big part of teachers are oriented towards the application of a number of

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multimedia products and interactive materials for visualization of specific problems of curriculum content in chemistry, process simulation.self-study, estimation and self-estimation of knowledge. According to them, the use of interactive materials and ICT in the learning process provides not only for the diversification of presentation of learning content but also for the implementation of efficient control over knowledge absorption. Some of the teachers use their skills in ICT sphere to create interactive materials.*Enriching the learning content with scientific achievements* in the field of chemistry is an approach which expands the awareness of students and builds their lasting interest in science. Scientists and university professors support chemistry teachers in its implentation. For example, teaching of complicated chemical issues could be developed combining science and art, as “live scientific show” - such an innovative approach allows of complicated Chemistry and Physics issues to be presented to students in attractive and understandable way using simple and amusing experiments or so called “scientific toys”. *School projects, club activities and other extracurricular training in chemistry* are successful forms of work for the development of natural science literacy and a tool for cultivating skills for teamwork. According to
chemistry teachers the project work allows students to cultivate many new competences that will benefit their future development - to develop ability to deal with scientific information; to extend their knowledge of chemistry and to develop deeper interest in natural sciences; to apply ICT in demonstration of scientific results; to appreciate the importance of natural sciences for everyday life; to learnt how to work in a team and make good friendships etc.[19]. The need to develop key skills and cultivate scientific literacy among students is a major task of Bulgarian high school education and is indicated in the project for new State educational requirements and curricula content and programs in chemistry and environmental protection comply with it.

3 Examples of Bulgarian successful experiences in teaching chemistry at school

3.1 Approaches for development of key competences and their application in chemistry education

Problem-based learning is a very innovative but at the same time a difficult to apply approach which requires serious self-preparation and a drastic change in the way that teachers perceive the classroom. A method of using a problematic approach in teaching chemistry in school was experimentally applied in chemistry lessons on Organic chemistry, according to the 9th grade syllabus in Comprehensive High School - Mirkovo. The idea was to assist the acquisition of useful knowledge and the formation of key skills of students as: defining scientific problems, scientific explanation of natural phenomena and processes, ability to analyze information in various forms (in this case with text and graphics). As the Problem-based learning in its traditional version has a proven positive effect on all of these skills, the methodology used by the teachers’ team adhered to its principles as follows:

- The class is divided into groups of 5-6 students who stay together for the whole term.
- Students are given problems that are directly related to their daily lives and raise their interest, solving of which requires application of the key skills we aim to develop.
- Two main approaches are used to present the problem – in the first case it is presented before the students have received all the necessary information and in the second case the students learn a concrete scientific concept and then are given the chance to solve a complex problem by using it.
- It is expected that the students will look for information on their own – in some cases they receive specific guidance and in others are left completely on their own.

The research was conducted with 15-16-year-old students in two classes. One of the classes was the control group, while the other one was the experimental group. During the research the students from the test group received problems every week by e-mail. They had to submit the solutions within seven days. Each problem was aimed at forming certain skills and had a specific way of presenting the solution and the way in which it was reached.
A test was conducted at the end of the research. The test contained 8 problems divided into three groups, aimed at assessing the level of attaining certain key competencies.The results allowed authors to come to the conclusion that “applying even elements of problem-based learning affects positively the formation of

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important skills and motivation for studying in students". But they also faced some problems during the experiment - students desire to receive feedback on the proposed solutions as soon as possible, which leads to necessity of in time and regular control of their work by the teacher. The problem is that most of the Bulgarian teachers do not have the habit of fast and timely revision of student work, regardless of the resources. So *to be the experimented method effective the change should not be in the methodology, but rather in the attitudes and way of thinking of teachers* [20].

A good practice in *application of solving problems approache* in Chemistry education is the National contest for key comepences in natural sciences which is held annually ever since 2009 among students from 5th to 11th grade of Bulgarian school [21]. It aims to stimulate students in acquisition of key competences in natural sciences, including chemistry – to express their own opinion considering important for the society issues, to develop innovative thinking, to present original ideas, to demonstrate key competences in solving problem in unknown conditions. In the field of chemistry the contest includes solving and public presentation of problems, demonstrating of key competences as knowledge about basic principles of the nature, critical viewpoint and assessment of the science advance, and its influence on the individual and the society. The participants should demonstrate knowledge on materials, substances and mixtures, natural and chemical processes, measurement devices, organization of scientific experiment, health and ecological culture etc. Some of the problems in the external evaluation tests and state exams are also of the same kind. Their answer requires knowledge not only in one but in several subjects as well as team work and communication.

A model for *building of specific competence on chemistry and environmental protection* was created and experimented in National High School of Science - Sofia. It is based on the curriculum of Chemistry and environment protection for 10 grade and aims at developing specific skills, such as:

- *Knowing* basic principles, laws, patterns and concepts in chemistry
- *Readiness* for scientific explanation of chemical processes and phenomena;
- *Skills* for use of scientific data and evidence
- *Skills* to perform observations, measurements, recording and analysis of the data
- *Skills* for planning of chemical experiments and construction of equipment and tools for conduction of experiments;
- *Skills* to identify problems in environment and find solutions and prevent new problems;
- *Skills* for research and select proper information;
- *Digital competences* – use of multimedia technologies in order to extract, estimate, store, create, present and exchange information;
- *Analysis* of information (reading comprehension)

The technology of competence forming and defining includes the application of a number of didactic materials and research of the results of the model implementation. According to the authors, „the attitude of students towards mastering key basic competences changed in a positive direction under the influence of the applied competence approach". They are aware and motivated to continually improve their achievements, to search for reasons for problems and to create and use algorithms for solving them, to cooperate with others for the accomplishment of mutual goals [22].

Combining of problematic approach with experimental laboratory work leads to development of pedagogical model, based on the idea that it is necessary to follow the path from theoretical knowledge to its application in different situations. Such a model was implemented in chemistry laboratory exercises for work with substances in 9th grade of Comprehensive High School "P. Beron" (Pernik) [23]. Experiments included have a practical implementation. A part of them are selected from the curriculum content and are supplemented with others, also useful and interesting to students. They help to build skills for work with substances, also for selection of substances in everyday life - food, detergents, mineral water, alcohol consumption, use of synthetic fibers and plastic. All developed problems give the students options for additional work on a topic selected by them and its presentation through posters, papers etc. Survey conducted among the students, gives information about the attitude and way of perception of the implemented laboratory work – most of them find laboratory work very useful, because it helps to memorize

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the curriculum content easier. The laboratory work motivates them to search for information also. Most of the students have discovered experiments which can be used in everyday life.
The teachers' opinion is that the model gives very good opportunities for work on experimentally-logical problems with research character, which leads to more lasting knowledge and skills of students. At these classes they are more focused, express opinions, suggestions and construct scientific hypotheses [23].
One of the main questions which educational specialists face at all levels is about the sense *of the* ***e-learning*** and whether the ***application of ICT*** can change the quality of teaching in the particular learning environment of Bulgarian secondary schools. In response to the question a model for e-learning of chemistry and environmental protection in 9th grade and e-multimedia resources (modules) for information provision (multimedia presentations, electronic versions of tests, instructions etc.) have been created in order to overcome the low efficiency of teaching chemistry in high school [24]. The model was experimentaly implemented in chemistry classes in Sofia high school of bakery and confectionery technologies. The diagnostic research conducted after the study aims at identifying positive changes in learning achievements and motivation of students when using the proposed model in the training process. The research took place in two stages – preliminary study and actual study on two of the studied sections – „Hydrocarbons" and Hydroxyl derivatives of hydrocarbons". Four groups of students participated in the experimental study. Groups' composition is identical in terms of gender, social status of the family, ethnicity etc. and also performance (up to the beginning of the experiment): the first group studies using the e-learning model; the second and the third group study combining traditional method + e-learning in theoretical and experimental work, and the fourth group is a control group which is trained using the traditional method without the use of ICT. The results of the creativity test conducted after the end of the training intended in the study show that the biggest difference between the results of the preliminary and final test belongs to the group which was trained using entirely e-model; lowest growth belongs to the group which was trained following the traditional model. These results give reasons for the author to conclude that the proposed model for e-training helps to improve the educational achievements of students, has a positive effect on motivation for studying and development of creativity and offers a flexible approach to solution of problems of low performance in chemistry and environmental protection training [24].
As it was mentioned above, chemistry teachers consider the ***use of interactive materials and ICT in the learning process*** as effitient way for diversification of presentation of learning content and as instrument for the implementation of efficient control over knowledge absorption also. They also try to develope such interactive materials using their own skills in ICT sphere. An electronic handbook on Chemistry and environmental protection, an algorithm for its use in the educational practice as well as the results of the pedagogical research on its application in the study of the section Initial review in 8th grade of Secondary specialized language school - Plovdiv. The electronic handbook is a software product for review, self control and self evaluation – after the end of the final test, students assess themselves using the six-point scale and the total number of points converts to a numeric score. The content of the handbook is structured as per the sections in the curriculum and Chemistry and environmental protection textbooks and covers „Basic terms", „Chemical symbols (chemical formulae and chemical equations) and valency", „Chemical nomenclature. Formulae and names of some of the studied chemical compounds". Each of the topics includes key words, short explanations of the key words, examples and test problems. In author's opinion the use of electronic handbook gives options for independent studying, increases the interest in the subject Chemistry and environmental protection through the use of computer, enables easier summarizing and systematizing of knowledge, stimulates cognitive interest, activity, independence. It also contributes to the development of self control and quick self evaluation and development and aquiring of mental and active competence.
A short algorithm is presented for the *use of the electronic handbook* for initial review in the educational practice.
Positive and negative aspects of the handbook use are presented from teacher's point of view:

- Positive aspects: easy update of the curriculum, option for multiple use of training materials; option for automated control of knowledge and practical skills; option for increase of interest in the subject and students' motivation for learning.

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- Negative aspects: need for computer work training and application of ICT; the creation of electronic handbook is complicated and takes time; not all pedagogical approaches can be implemented through the use of ICT.

The results of the experimental use of the handbook in the training process show that an extremely favorable atmosphere is created in classes and the work is much more effective. The given handbook is interesting, attractive and useful for students and motivates them to acquire new knowledge and skills.The results and observations of practical work also show that the applied methodology of work leads to increased interest in e-learning, curiosity transformed to lasting interest and achievement of expected results from training. The model presented is fully applicable to any school subject [25].

A way out of this tangle is the Chemistry lessons in the educational platform Ucha.se [26]. The videos interpret understandably basic Chemistry knowledge which lies in the obligatory syllabus from 7 to 10 grades.

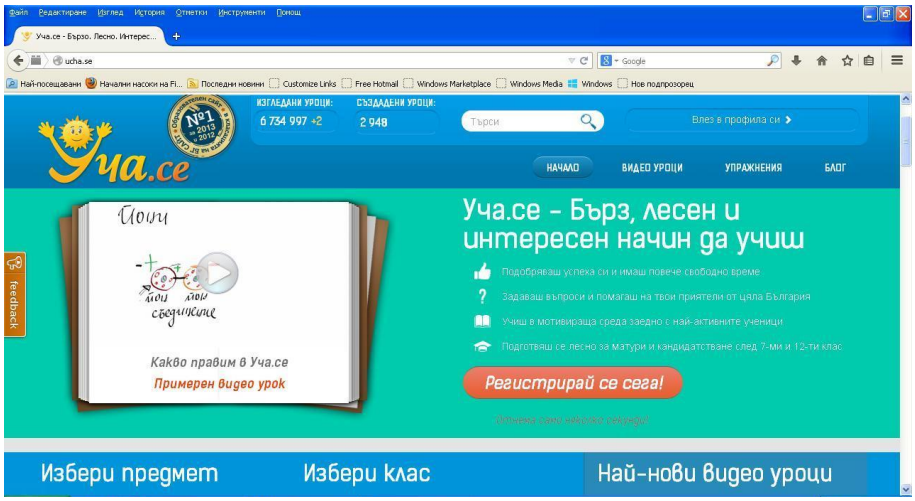

Fig.1. Web-portal of Ucha.se with Chemistry video-lessons

They are short – the matter is presented in 10-15 min, using also jokes, interesting stories or situations close to the students' life. There are over 150 videos created for Chemistry. The platform users especially appreciate the video exercises where they can apply skills in solving different tasks. In the different grade sections there are lots of tests by which students can check their level of knowledge after certain unit or before forthcoming exam in school. The statistics show that users - students, university students, teachers, parents, even people of various ages find the learning from video-lessons effective and entertaining. In a one and a half year the videos have collected more than 2.5 million watches - this proves the need of such education (Fig.1). This way of learning has many advantages: learning from video-lessons is effective and entertaining - it's not torturing and students learn with pleasure; the platform is very communicative – there is possibility for asking questions, commenting problems, online chatting and asking question in real time; video-lessons are particularly useful for students which absent from school and cannot study the lessons from the textbooks on their own. In the future subtitles will be inserted in the videos in order to be accessible by children with hearing impairment. The platform will offer also special forum for sharing successful experience in teaching Chemistry (presentations, video materials etc.) of Chemistry teachers from the whole country [27].

Enriching the learning content with scientific achievements is a very successful practice, which has been developed last few years in Private American College in Sofia. It is performed as "live scientific show" combining science and art in teaching of complicated chemical issues. The author of the show is a Science communicator and Chemistry teacher at the same time. Such a show "On the edge of science and art" was

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demonstrated during *International Conference on Training Issues of Chemistry Teachers* in June 2013, in Gabrovo.
Realising the importance of the chemical experiments in building of students' key competences suxessful experience and practice was experimented by the creators and participants in the ***Portable chemistry laboratory for students Chemgeneration Lab*** – a common initiative of BASF (Bulgaria) and the Faculty of chemistry and pharmacy of Sofia University.

Fig.2. *Chemgeneration Lab:* Chemical experiments at school with the participation of talanted students from Faculty of Chemistry and Pharmacy of Sofia University

The purpose of this laboratory is to create an opporunity for experimental work in chemistry for students from 6th to 12th grade with declared interest in chemistry. The laboratory travels to schools in Sofia and the country and unfolds in the host schools. Within one session of 1-2 hours up to 15 students are able to make some experiments, corresponding to their age and under the guidance of the hosts - outstanding students of the Faculty of chemistry and pharmacy (fig.1). Experiments are selected in a way that they are both fun and spectacular and as safe as possible. After the implementation of the experiments the host explains the observed phenomena and show their relation with the learning content taught at school. Over the last year the laboratory visited a number of schools in the country and the interest towards it continues to grow – this is also proved by the schedule which is full for the next year [28].
The practice of ***developing school project,*** applied as a form of partnership between schools with different profiles and level of chemistry learning adds more positives in favor of the efficiency also as an educational tool - interschool partnership allows the integration of students into a new school environment, shows new ways of learning and develops abilities for teamwork. This is a conclusion made by teachers in American College Arcus and Vocational School of Electronics - V. Tarnovo based on their common work to develop a school project which involves students from both schools. This partnership has another positive effect within the environment of the Bulgarian secondary school: it gives the opportunity to students from schools with insufficient or no laboratory base which are most of the schools in Bulgaria, to participate in experimental work in chemistry which increases students' interest in the subject [29].

4 The Impact of the Project on Successful Experiences

4.1 Workshops

Last project year of Chemistry is all around Network project was dedicated to Successful experience and good practice in teaching chemistry at school. On this thematic area two workshops on Successful

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experience and good practice in teaching chemistry at school were held within the national network and with the active participation of teachers and experts.

National Workshop on "Successful experience and good practice in teaching chemistry at school" was held on 14th of March 2014 in Technical University of Gabrovo (Fig.3). It was attended by chemistry teachers from secondary schools associated of the Technical University - Gabrovo project, as well as representatives of universities and organizations as experts. The meeting included two thematic discussion sessions and a practical teamwork. During the first *discussion "*Teaching chemistry at school: innovative approaches and good practice" *teachers and experts involved in Chemistry Network Project* commented on papers and publication on Suxessful experience in teaching chemistry at school, available on the project portal. Partners' pedagogical experience described in publications as **"**Activity approaches by teaching chemistry - prove pedagogical experience from educational practice" (Slovak Republic), "Chemistry teachers inventions fair" and "High school science talents" (Czech Republic), "English for chemistry: film bank" (Poland), „A Science Teacher Education Course in a Science Centre: A Successful Strategy to Empower Teachers to Master Museum Resources Exploration?" (Portugal), "Design, development and implementation of a technology enhanced hybrid course on molecular symmetry: students' outcomes and attitudes" (Greece), "Virtual chemistry laboratory: effect of constructivist learning environment" (Turkey) etc., was analysed considering possibility of its implementation in Bulgarian school education. Some of the comments related to the lack of language skills as a limitation factor for application at school of large number of existing interactive materials in chemistry, the limited number of chemistry classes in Bulgaria which do not allow individual work with talented students etc. According to both teachers and experts, among the partners' papers on successful experience available on the project portal the most interesting are "English for chemistry: film bank" (Poland), „On-line chemistry education for talented students" (Czech Republic).

During the second discussion teachers and experts commented some aspects of experimental testing of interactive materials, available on the project portal in the chemistry classes. They were carefully identified by chemistry teachers at the end of the second project thematic area, on the basis of criteria like school profile, level of students' knowledge, available technical equipment. Chemistry teachers approved materials to be tested at school, for example PhET**,** Virtual chemical laboratory http://chemgeneration.com/bg/, http://www.learner.org/resources/series61.html etc. Experimental Chemistry lessons will be held across the network of schools associated with the project with the help of the "Ucha.se" administrators as a result of the various, attractive interactive materials available there. Some problems related to organization of testing, development of additional methodological and supporting materials, systemizing and analyzing of testing results and getting feedback from the students were also discussed.

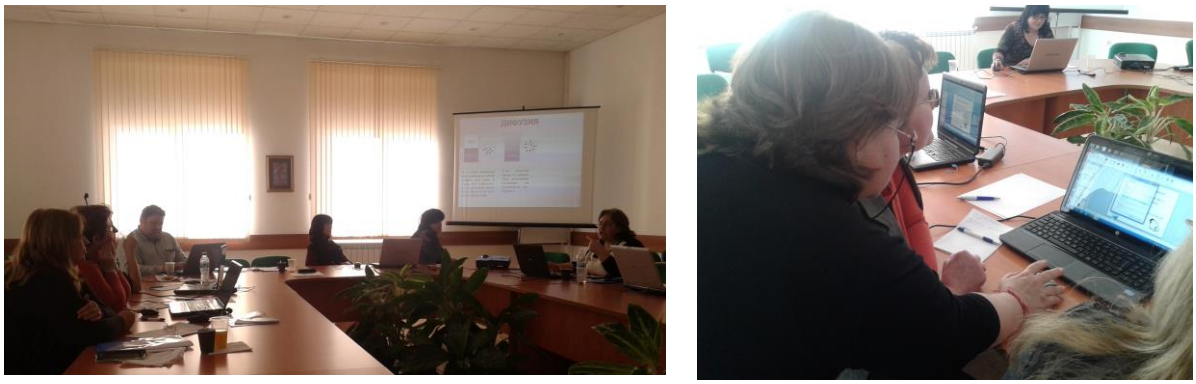

Fig. 3. National Workshop on "Successful experience and good practice in teaching *chemistry at school*

The second part of the meeting was organized as practical workshop on application of specific software in development of educational content. The workshop was held with the methodological assistance of assoc.

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prof. Milena Kirova from Sofia University, expert in audiovisual technologies – teachers divided in small groups, with the methodological and technical support of the experts tried to develop a part of school lesson related to "Chemical bonds", applying animation techniques, and necessary supporting materials also.
At the end of the meeting the participants concluded that:

- Popularization of successful teaching experience and practices is a way to help the chemistry teachers in their efforts and contributes to restore the students' motivation to study Chemistry. In this sense Chemistry Network Project plays important role because trough the project network helps proved successful pedagogical experience and good practice to be shared with chemistry teachers from large number of schools in European countries;
- Achievement of scientific literacy and development of key competences in natural sciences as final result is a complex process influenced by many important factors as: quality of educational curricula and programs in terms of their volume and content; teacher's role and methodological skills - to present the educational content, to apply innovative approaches to involve students in the educational process, to work individually with talented students, etc.; adequate technical support etc. It is important to popularize successful experience not only in application of ICTs to present the educational content in attractive and understandable way (although it is obviously one of the preferable approaches to enhance students' interest to in chemistry) but this one related to development of methodological and didactic materials, evaluation of students' knowledge and teachers' training also.

Having in mind some specific features of Bulgarian education system, teachers and experts consider that following partner's practice could be successfully implemented and contribute to motivate students to study chemistry:

- Close collaboration „Business – University - school " as instrument for motivation both students and teachers (good practice in Czech Republic and Poland) ;
- Development of internet-"bank" for exchange of tested in the practice interactive educational materials in chemistry, accessible by all chemistry teachers in Bulgaria;
- Personal work with talented students, like in Czech Republic.

Transnational virtual workshop on Successful experience was held on 10th of April 2014. It was organized by Pixel (Italy) and attended by teachers and experts from 11 countries. Bulgaria was presented by two Chemistry teachers - representative of Aprilov National High School, Gabrovo, two teachers - representatives of Vocational High School of Electronics, V. Tarnovo, an expert - Chief expert in Natural sciences and Ecology from Regional Inspectorate of Education, Gabrovo, the Project contact person and a member of the Project technical staff from Technical University of Gabrovo. During the workshop spoke person for the teachers presented the main results of the national workshops on Successful experience and good practice in teaching chemistry at school. The workshop became a forum where good practices and successful pedagogical experience from 11 European countries was shared and discussed.

4.2 Testing of ICTs

The strategy of experimental testing of interactive materials, available on the project portal in the chemistry classes was discussed with chemistry teachers and experts involved in the project activities. The materials to be tested were carefully identified by chemistry teachers at the end of the second project thematic area, on the basis of clear defined criteria like school profile, level of students' knowledge, available technical equipment. Following factors limited the choice of teaching resources for testing in chemical classes: language of the teaching resource; level of students' basic knowledge; lack of laboratory equipment; lack of computers and other supporting technical equipment; level of teacher's competence to use ICTs.
Nine interactive teaching resources have been chosen to be experimentally tested in the real chemistry teaching/learning process at 6 schools involved in the project activities – among them 5 project partner schools and 1 associated school. The testing procedure was performed by 11 chemistry teachers - 9 from

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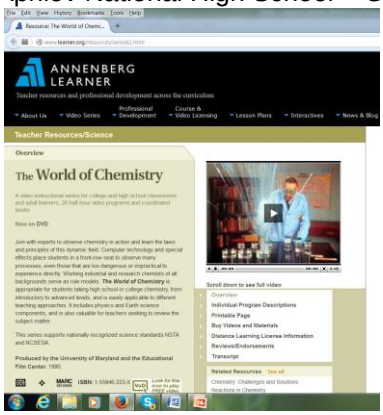
the partner schools and 2 from the associated school. 175 students 8 – 10th grade from Bulgarian secondary school attended the testing: 162 in regular chemistry classes and 13 in research club activity.

- ***Resource 1: The world of chemistry (Carbon) (http://www.learner.org/resources/)*** – tested at Aprilov National High School – Gabrovo (10th grade, 24 students, specialized English language education).



Reasons to choose the teaching resource were: the easy and understandable way to present basic knowledge; special effects and animations enable simulation of processes, dangerous for real lab visualization.
Learning topics: to show the chemistry in the real life, to rise students motivation and to motivate them to self education.
Students' reaction: they find the material interesting, easy to understand and efficient; it provokes the curiosity to the world around us, to the meaning of chemical knowledge in everyday life and to forming of proper attitude towards health care and environmental protection.
Teacher's conclusions: Use of material had a positive influence on implementation of objectives of chemistry education; the topic is directly linked to applications, including industrial and environmental problems enounced through opinions of representatives of academic and industrial sphere; it offers efficient approach to mastering chemistry knowledge through improving of English language.

- ***Resource 2: Explore & Discover Chemistry!*** *(http://chemgeneration.com/bg/)* – tested at Vocational High School of Electronics – V. Tarnovo(9th grade, 18 students, ICTs education) and Private specialized High School "American Arcus College" – V. Tarnovo (9th grade, 18 students) by chemistry teachers Galina Kirova and Jenna Staykova.

Reasons to choose the teaching resource: enlarges the basic knowledge; allows integration of science in educational content and visualization of 3-dimensional structures; combines learning with entertainment.
Learning topics: to enhance students' motivation, to present advances in science and technologies, to develop notion about environmental sustainability.
Students' reaction: they like the idea of team working with students from other schools*;* the resource is easily accessible and promotes students' self study. The most liked are electronically presented animated models and varied interesting information*.*
Teacher's conclusions: the resource ensure utilization and interpretation of educational content by stimulating the student's cognitive activity; it provide the student with motivation and willingness to learn.

- ***Resource 3: PhET*** *(http://phet.colorado.edu/en/simulations/category/chemistry)* – tested at Vocational High School of Electronics and Chemical Technologies – Pleven (9th grade, 13 students) by Radka Krasteva, chemistry teacher involved in the Project.

Topics related to the resource are: Chemical equations balancing; Isotopes and atomic mass; Atom and molecule structure.
Reasons to choose the teaching resource were: Suitable educational content; Possibility to visualize processes with simulations; allows presentation the content in amusing and understandable way.
Learning topics: generation of simple atom models; visualization of chemical bonds*;* development of stereo-imagines about molecule structure

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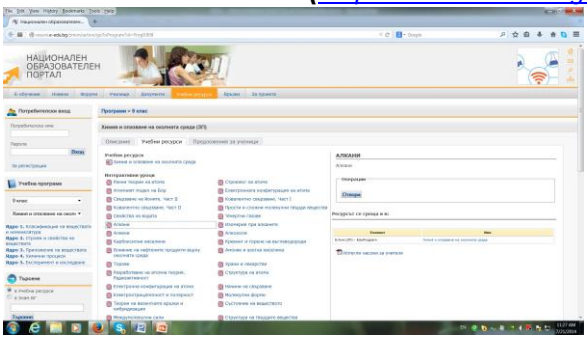
Students' reaction: Students tested the simulations with great enthusiasm and enjoyed learning chemistry by using computers.
Teacher's conclusions: Interactive simulations are easy to use and of a good scientific value. Through them, the teacher can receive feedback, whether the learning content is absorbed. When used appropriately by the teacher, they can increase students' interest in studying the subject. Through these simulations, by having fun the students can demonstrate and apply what they have learned. They are very suitable in lessons for exercise and summary, as well as new knowledge with difficult theoretical concepts, which through them are presented in a very accessible and understandable way /e.g. atomic structure, chemical bonds, etc./

- ***Resource 4: Alkanes (*** *http://resursi.e-edu.bg/zmon/action/goToProgram?id=Prog9.908)* – tested



at Vocational High School of Electronics – V. Tarnovo (9th grade, 18 students, ICTs education) by Galina Kirova, chemistry teacher involved in the project.
Reasons to choose the teaching resource were: Covers a great part of educational content relate to alkanes; Visualizes the bonding between carbon atoms; Allows visualization of burning process.
Learning topics: to develop knowledge about alkanes; analyzing of chemical properties through chemical experiment.
Students' reaction: Students like the diversified lesson in different learning environment - computer lab; they recognize the role of self-study and self-examination of knowledge in the course of the lesson; the demonstrations watched also attract their attention

Teacher's conclusions: the tested resource Increases skills for visualization of content and understanding of concepts; it helps to develop self-study skills for the designation of a given formula, to draw patterns in chemical formulas, to associate properties with application, to transfer acquired knowledge and skills in a new unfamiliar situation.

- ***Resource 5: Virtual chemical laboratory (*** *http://chemistry.dortikum.net) -* tested at Vocational High School of Electrotechnic "M. V. Lomonosov" – G. Oriahovitza (10th grade, 26 students, specialized education in System engineering), by Petar Rachev, chemistry teacher involved in the Project.
Topics related to the resource were: Sulphuric acid (Chemistry content for 8th to 10th grade) and Compounds of aluminium.
Reasons to choose the teaching resource were: easy working and suitable education content.

Learning topics: development and performing of chemical experiment; work with scientific resources and handbooks.
Students' reaction: Students were interested in mastering new knowledge; they took pleasure in working with the product (most of them use the website at home).
Teacher's conclusions: The resource is very well structured and offers a wide range of options to teachers in the teaching process, by presenting the learning content in various methodological units. The activity and interest of students increased when they found themselves in a position to take independent decisions and apply them in situations related to specific chemical element..

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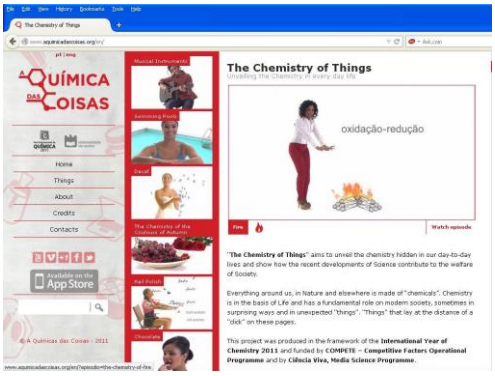
- ***Resource 6: A Química das coisas*** **(**http://www.aquimicadascoisas.org/en/) - tested at Vocational High School of Electrotechnic "M. V.



Lomonosov" – G. Oriahovitza (10th grade, 22 students) by Genoveva Ilieva – chemistry teacher involved in the project.
Topics related to the resource were: Why ethyl alcohol is protoplasmic poison – what happens with ethanol inside human body; is ethyl alcohol food, how does it affect organs in human body
Reasons to choose the teaching resource were: easy working, suitable education content; availability of equipment for implementation of the resource in the learning process;
Students' opinion: it allows repetition, systematization and summary of the matter; beside its educational effect it has emotional effect also.
Teacher's conclusions: the resource is useful because of

- Individual learning of something new in relation to the lessons learned in class and aspiration to clarify more thoroughly the studied phenomenon;
- Use of knowledge, skills and habits obtained during the lesson in other situations;
- Readiness to participate in the lesson and adequate emotional reaction;
- Expanding and improving knowledge.

- ***Resource 7: ChemistryOnlin****, Trends in the Periodic Table (http://askthenerd.com/chemistryonline /)* – tested at Vocational High School of Mechanoelectrotechnic – Sevlievo (9th grade, 26 students, specialized education in Computer Engineering, taking an intensive English language course) by Krasimira Tomeva and Rositca Dimkova – chemistry teachers involved in the project.

Reasons to choose the teaching resource were: easy working, suitable education content.
Learning topics were: to enlarge the students' knowledge about the chemical elements
Students' opinion: they enjoy using the resource as all the notions and relations they consider difficult and abstract are explained in an interesting, user friendly way. It helps them learn the relations in the periodic system and they are willing to use it in other chemistry lessons.
Teacher's conclusions: the resource conveys great amount of information and facilitates the study of the theory for the atomic construction and the chemical elements. The combination of videos, pictures, experiments and interesting facts about the substances make the resource interesting for students. The successful resource testing was also due to the students' linguistic and computer skills, as well as the modern labs at the school.

- ***Resource 8: Learn Chemistry (*** *www.rsc.org/learn-chemistry)* – tested at Vocational High School of Mechanoelectrotechnic – Sevlievo (26 students, specialized education in Computer systems with English language learning and 13 students, 8-10th grade, members of „Research laboratory" club) by the same teachers, as mentioned above.

Topics related to the resource were: chemical elements (metals and non-metals); Interactive Periodic Table
Learning topics: developing of skills in formula writing and determination of chemical bonds
Reasons to choose the teaching resource were: easy working; suitable education content.
Student' reaction: Students like the website and have preferences to videos, simulations and experiments - according to them, these materials increase the interest in chemistry, contain synthesized and interesting

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information, facilitate the study of lessons; experiments produce largest discussions, as students consider them interesting – they contribute to the exploring of the real world. *Teacher's conclusions:* the website is very attractive and very well structured - it offers a wide range of materials and enables teachers to share and exchange ideas and materials. It contributes not only to the development of competences in natural sciences but also the ones of digital and linguistic skills; it's use is only limited by the need of good command in English**.**

- ***Resource 9: National Education Portal*** *(http://resursi.e-edu.bg/zmon/action/)* – tested at Vocational High School of Electronics and Chemical Technologies – Pleven (9th grade, 15 students, specialised education in Chemical Products and Technologies) by Daniela Petrova – chemistry teacher involved in the project.

Reasons to choose the teaching resource were: rich educational content, suitable both for theoretical and practical classes; *t*he teaching resource is in Bulgarian language;
Learning topics were: Use of e-lessons in chemistry classes – theory and practice.
The results are still expecting.
In general, reaction of the students involved in teaching resources testing could be by defined as very positive. They were "interested in mastering new knowledge", "enjoyed learning chemistry by using computers, electronically presented animated models, simulations", videos. According to them, these materials increase the interest in chemistry, contain synthesized and interesting information and facilitate the study of lessons. Students consider chemical experiments as the most interesting because they contribute to the exploring of the real world. Using these teaching resources, many of them recognize the role of self-study and self-examination of knowledge in the course of the lesson. For example, the personal opinions of some of them are presented below:

- "The resource is interesting and very well presented. I liked videos the most. Materials are quite good, they are easy to understand and master. Simulations are of great use, too. This type of studying stimulates us and helps us explore many things from real life. I play sports and „Chemistry and sport" section was interesting to me" (*Vasil Dochev* – student, member of "Research laboratory" club Vocational High School of Mechanoelectrotechnic – Sevlievo", about "*Learn Chemistry"*);
- "The learning resource is presented very well - this definitely attracts student's attention. I like presentations, videos, games. It's useful, especially for things which one cannot otherwise see. Illustrations are quite good. They are stimulating and motivating. We have discussions mostly about presentations and materials intended for students. It's easy, as far as „easy" corresponds to chemistry. To me, chemistry is a difficult science and this website helps me a lot when I study (Inna Petkova, student, „Computer systems" with English language learning, Vocational High School of Mechanoelectrotechnic – Sevlievo, about "ChemistryOnlin".
- If it is necessary to summarize teachers' considerations, few important points should be marked:
- Use of interactive teaching resources has a positive influence on implementation of objectives of chemistry education. ICTs based educational products ensure utilization and interpretation of educational content by stimulating student's cognitive activity and provide with motivation and willingness to learn.
- Some of the resources help students to develop self-study skills for the designation of a given formula, to draw patterns in chemical formulas, to associate properties with application, to transfer acquired knowledge and skills in a new unfamiliar situation;
- The combination of videos, pictures, experiments and interesting facts about the substances make the resource interesting for students
- Especially about the simulations:
    - Interactive simulations are easy to use and of a good scientific value;
    - Through them, the teacher can receive feedback, whether the learning content is absorbed.
    - When used appropriately by the teacher, they can increase students' interest in studying the subject.

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- Through these simulations, by having fun the students can demonstrate and apply what they have learned;
- They are very suitable in lessons for exercise and summary, as well as new knowledge with difficult theoretical concepts, which through them are presented in a very accessible and understandable way

- Besides of the quality of the teaching resource, its successful implementation in the real educational process depends in large degree on the students' linguistic and computer skills, as well as the modern equipment at the school also.

5 Conclusions

Achievement of scientific literacy and development of key competences of students become one of the main objectives in natural sciences and particularly Chemistry training in Bulgarian school education. This is a long process which quality and final results are influenced by factors as quality of educational plans and programs in terms of their volume and content, modern and adequate technical support, implementation of ICTs in educational process.

Crucial for the successful implementation of this objective is the leading role of teachers and their skills to present the educational content,in attractive and understandable way, to involve students as active participants in the educational process, to develop their scientific and innovative thinking, and ability for team working. To perform this role Bulgarian chemistry teachers apply innovative approaches as problem-based approach (solving of context-based real-life problems), experimental work (hands-on activities), project-based and inquiry-based learning.

To make these approaches effective and to improve the quality of Chemistry education, teachers implement ICTs in school educational practice – multimedia, interactive teaching materials, e-learning etc. – to make the complicated chemical content more understandable, to stimulate students' activity and to direct their interest toward chemical science. The utility of interactive ICTs based teaching materials was proved by the results obtained during the experimental testing of selected by the chemistry teachers educational products in the real process at Bulgarian secondary schools – the common opinion both of chemistry teachers and students is that the implementation of ICTs in Chemistry education and use of interactive teaching resources facilitates students in understanding of complicated educational content, helps the chemistry teachers in their efforts and contributes to restore the students' motivation to study Chemistry.

6 Bibliography and References

[1] International Conference on Training Issues of Chemistry Teachers (TICT)
[2] http://www.diuu.bg/ispisanie
[3] Konstantinova, V. Contemporary Possibilities in the Chemistry Education for Building Positive Motivation and Strong Interest to Natural Sciences. Proceedings of International Conference on Suxessful Experiences and Good Practices in Chemistry Education, 21st May 2014, Braganca (Portugal).
[4] Tomeva, K. Approaches to Developing Key Competences in Natural Sciences. Proceedings of International Conference on Suxessful Experiences and Good Practices in Chemistry Education, 21st May 2014, Braganca (Portugal).
[5] Kirova, G. and J. Staykova. Integrative Internet-Based Case Study for Sustainable Development. Proceedings of International Conference on Suxessful Experiences and Good Practices in Chemistry Education, 21st May 2014, Braganca (Portugal).
[6] http://www.azbuki.bg/en/
[7] http://khimiya.org/scope.htm
[8] http://www.azbuki.bg/en/editions/journals/strategies
[9] http://www.azbuki.bg/en/editions/journals/pedagogics
[10] http://www.diuu.bg/ispisanie/
[11] http://www.minedu.government.bg/opencms/export/sites/mon/left_menu/projects/unesco/sbornik-dobri-praktiki.pdf

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This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

[12] http://start.e-edu.bg/
[13] http://www.teacher.bg/
[14] www.EQF_bg.pdf]
[15] http://ec.europa.eu/education/policies/2010/doc/basicframe.pdf
[16] Tafrova, A. Contemporary trends in pupils' Science education, Bulgarian Journal of Science and Education Policy (BJSEP), Volume 7, Number 1, 2013, pp 121 – 200.
[17] Kirova, M., E. Boyadjieva, V. Ivanova. Active and interactive learning in „Chemistry and environment" school subject 7th and 8th grades, Pedagod 6, Sofia, 2011.
[18] Kirova, M. Interactive multimedia as an instrument for presentation of Chemistry educational content. Proceedings of International Conference on E- learning and distance education, April, Sofia, 2011, pp 288-295 (in Bulgarian).
[19] Nikolova, M. Setting up a scientific school project as a method of increasing students' motivation for studying natural sciences and ecology. Proceedings of International Conference on Innovative Learning in Chemistry, December'2012, Prague, Czech Republic.
[20] Tzvetkov, Vl., E. Boiadjieva. Application of the problem-based approach in chemistry classes. Proceedings of International Conference on training issues of Chemistry teachers, 26th of June 2013, Gabrovo, Bulgaria.
[21] http://www.minedu.government.bg/opencms/export/sites/mon/left_menu/olympiad/regulations/2012-2013_nc_key_comp_PNE.pdf
[22] Dyankova, N. Education-cognitive tasks for implementation of key competences approach in Chemistry and environmental protection classes in 10th grade. Lifelong education (e-jurnal of Department of information and teachers qualification, Sofia University), N 29, 2012 (in Bulgarian).
[23] Ganeva,M. Practically oriented experimentally-logical problems in chemistry laboratory exercises in 9th grade. Lifelong education (e-journal of Department of information and teachers qualification, Sofia University), special edition, 2012, pp 505 – 515, (in Bulgarian).
[24] Pangalova, V.Chemistry and environmental protection e-learning in 9th grade. Continuous education (e-jurnal of Department of information and teachers qualification, Sofia University), N 21, 2011 (in Bulgarian).
[25] Chekanova, D. Electronic handbook application model at the initial review on chemistry and environmental protection in 8th grade, Lifelong education (e-jurnal of Department of information and teachers qualification, Sofia University), N 25, 2011 (in Bulgarian).
[26] www.ucha.se
[27] Hikolova, M., D. Madjarov. Online video lessons on the platform "Ucha.se" (http://ucha.se/) – innovative approach for high quality education in Chemistry, Proceedings of International Conference on Training Issues of Chemistry teachers, 26th of June 2013, Gabrovo, Bulgaria.
[28] https://www.facebook.com/ChemgenerationBulgaria
[29] Kirova, G. and J. Staykova, "Earth belongs to all of us" – an interschool project on the impact of mineral fertilizers. Proceedings of International Conference on Training Issues of Chemistry teachers, 26th of June 2013, Gabrovo, Bulgaria.

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