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CHEMISTRY IS ALL AROUND NETWORK

518300-LLP-2011-IT-COMENIUS-CNW

Successful Experiences in Chemistry Teaching in Slovakia

Lifelong Learning Programme

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SUCCESSFUL EXPERIENCES IN CHEMISTRY TEACHING IN SLOVAKIA

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Abstract

Situation in Slovakia in the field of successful experiences in chemistry teaching is very interesting because in most of the Slovak primary and secondary schools is teaching approach and teaching methodology very traditional. On the other hand we have in Slovakia very successful projects and approaches and teachers which are using new ICT technology in teaching chemistry and new pedagogical approaches as you can see in our examples of successful experiences. The first one is the pedagogical and psychological art of the teacher who has the freedom to create the curriculum of the subject and choose the method of teaching. The second is connection of education with real life. Successful projects were realized on national level – Modernization of education process in secondary schools in Slovakia but it mostly about individual teachers activities which will teach chemistry on another way with new methods and approaches.

1. Introduction

In Slovakia can chemistry teachers use many very good and interesting resources to take information about successful experiences and new approaches in teaching chemistry on national and international level. Problem is the language problems from this reason our teachers use mostly Slovak and Czech resources. On our Slovak organised international Conferences about teaching chemistry participated mostly experts and teachers from Czech republic and Poland because this languages are understandable for our teachers and for practical using new experiences in teaching process. Our teachers can use following publications:

- ACTIVITY APPROACHES BY TEACHING CHEMISTRY - PROVE PEDAGOGICAL EXPERIENCE FROM EDUCATIONAL PRACTISE
- Jana Straková - Methodic-pedagogical Centre in Prešov
- COMPUTER SUPPORTED SCHOOL CHEMICAL EXPERIMENT AS MEANS FOR REALISATION OF INQIURY - BASED SCIENCE EDUCATION (IBSE)
- Martin Bilek, Jaroslav Hruby - Pedagocical Faculty University in Trnava, Intrnational Conference, Actual Trends in Teaching Chemistry, 2012
- E-LEARNING IN THE EDUCATION OF THE APPLIED ENVIRONMENTAL CHEMISTRY
- Melánia Feszterová - Faculty of the Natural Science at Constantine the Philosopher University in Nitra
- IRON, ALLOYS OF IRON AND THEIR PRODUCTION - MULTIMEDIA EDUCATION SYSTEM
- Luděk Jančař, Hana Šťastna - Pedagogical Faculty University in Trnava, Iternational Conference - Actual Trends in Teaching Chemistry 2012
- NEW GAMES ON CHEMISTRY FOR MORE ATTRACTIVE CHEMISTRY EDUCATION
- Petr Šmejkal, Michaela Šmejkalová - Department of teaching and didactics of chemistry, Faculty of Science, Charles University in Prague
- ON-LINE CHEMISTRY EDUCATION FOR TALENTED STUDENTS
  Hana Böhmová, Milada Roštejnská - Univerzita Karlova v Praze, Přírodovědecká fakulta, Katedra učitelství a didaktiky chemie
- PLANNING AND REALISATION CONCEPT OF THE INQUIRY – BASED SCIENCE EDUCATION IN SCIENCE EDUCATION

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Mária Orolínová - International Conference Smolenice 2012, Pedagogical Faculty Trnava University in Trnava

- USING INTERACTIVE WHITE BOARDS BY CHEMISTRY SCIENCE EDUCATION IN PRIMARY SCHOOLS
  Katarína Javorová - Pedagocical Faculty Trnava University in Trnava, International Conference - Actual Trends in Science Education

And many others.

2. Key competences and their development in chemistry education

Europe is changing and so is our society. It goes through some deep and wide changes that are accompanied with drop of trade increase, economic and politics crises and changes in the labor market. New technology is getting old in short time. Every sixth employee change his job during a year and each eighth even a field of his job in average [1]. Keeping the same job for whole life is a rarity. To learn how to learn and learn for the real life gets more important than pass along the knowledge that grow old very fast. Accentuate the acquirement of factual knowledge got useless also because of development of information-communication technologies (ICT) speeded up the communication and information are easier accessible. It is important to move the accent in education on the personal possibilities of students, their approaches and allover cognitive abilities “facilities”. It should be moved to their personal and social competencies. We build up our model of education on this base. The main problems we solve in our school projects:

- The creation of the subject curriculum with the teacher
- We used the newest world trends studies as a valuable information source. [2, 3, 4, 5] The teacher is the most important agent in forming the content and form of the educational process and so he is the creator of the subject curriculum. Our ideas of the content and form of the chemistry education aroused from this point.
- The connection of the real life and education
- The subjects are understood as science disciplines in classic education system in Slovakia. There is the intention to advise students with the whole range of their content. According to the intense boom of science and technologies is education even more apart from the real life. Students live their life of cognizance outside of school. They obtain there decreasingly less knowledge and skills useful in the real world. This we tried to change in our school program aiming the natural sciences content not to copy the subjects as the science disciplines.
- The need of complex view during study of natural phenomena
- Natural phenomena should be study in the complex view; therefore it means integration of knowledge, skills and attitudes obtained from the view of physics, chemistry, biology geography as well as social sciences. Methods and methodologies (Integrated Thematic Education – ITE, experience learning, Socrates dialogue, team work, etc.) aimed in this direction are used mostly in the classes.
- No need to teach everyone everything

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Nobody will probably doubt the fact that high school with general education (ISCED 3) should prepare students mostly for the study at university or other higher education institution (ISCED 6). The field range of higher education is so wide in this era, that it is impossible to prepare the student for all types of higher schools in the whole range and depth. The preparation has to be sooner or later specialized. Today education makes it more difficult for the student in the state schools in Slovakia. The student is forced to be dedicated to all the subjects' thorough whole study and there is lack of time for specialization. General education does not mean that the graduate should be polymath, who masters all the sciences. The training of key competences on the basic knowledge of the subject, the ability to understand some of the life situations, to sense their complexion, is considered to be the general education bases. Therefore, we support selection of subjects according to student's choice of higher education in the last two years of high school education at our school.

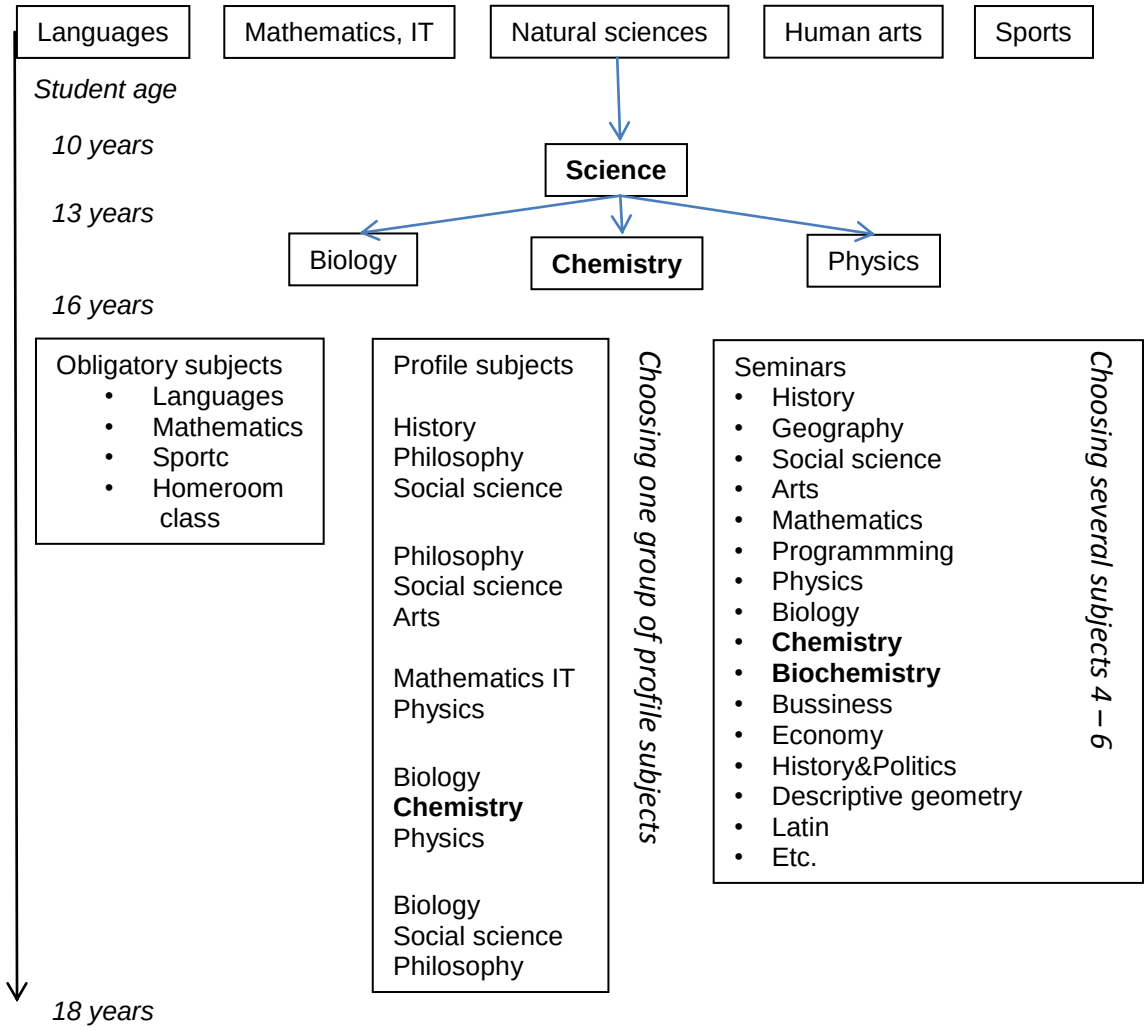

Fig. 1. Scheme of the school programme of the 1° independent high school

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I. The subject: “To learn how to learn” was added to our education program in 2004. We work with Raven Feuerstein instruments there. [6, 7, 8] We train two and three dimensional imagination before the atomic or molecular orbital image creation.

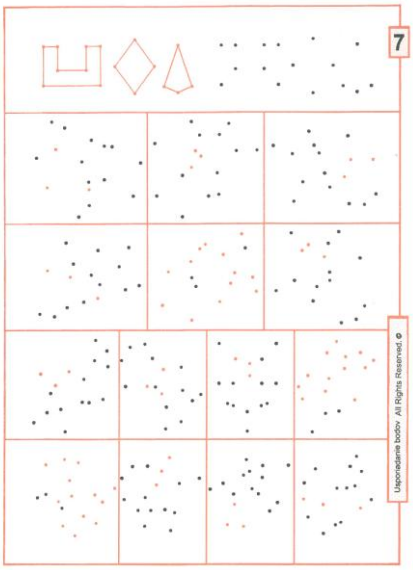

Fig. 2. Feuerstein instrument for 2D vision training

II. Students are thought to observe, register natural phenomena, conclude, verify and generalize the conclusion in the subject Science for 10 to 13 years old students with 4 classes of the laboratory work and 1 theoretical class per week.

III. Mutual themes of natural science subjects such as electrolysis, basic image of quantum physics and chemistry, physical consequences of chemical bonds are thought in classes with two teachers of both subjects.

Example of successful experiences – this one of our Slovak most successful experience in Slovakia on secondary school.

3. Education program for Chemistry and natural sciences of the 1st independent high school

We have education program based on: identification of the basic knowledge of chemistry, solution of the phenomena through the integration of natural sciences subjects, training of the key competencies.

3.1. Basic knowledge

Basic knowledge should be identified in such range that even student with minimal amount of information and experiences is able to work adequately with wide range of phenomena and manage to master even deeper content of the field by self-education. The basic knowledge should be the material, what all the key competencies are trained on. The basic knowledge of chemistry is presented in our school program as written below.

The study of chemistry begins practically in the level ISCED 1 in the subjects called: Discovering the world and Science. Students observe the natural phenomena. They learn to talk about them independently,

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describe them and induct them into the relations. The content integrates several natural and social sciences fields.
Second step continues in the level ISCED 2 in the subject Science in 4 classes' laboratory work and 1 theoretical class per week. Students receive the possibility to research the phenomena being in progress daily in their nearest surrounding and to experiment and search for answers to coming out questions. Formulating the questions and search for answers is crucial in these lessons. The main theme for further study of chemistry is the chapter: Substance structure. Student **creates image** of particles contained in the substance. Formation of the particles during Big Bang is represented by experiment of observed crystallization nuclei. Electron is presented as an electron cloud – shapeable balloon with special properties. Mutual force interaction between one nucleus and electrons of another atom is presented as a deformation of electron cloud and a creation of the chemical bond possibly expressed by change of newly obtained substance properties. Based on the chemical bond theory we later talk about physical and chemical properties of the gases, liquids and solid substances.
Further these created images lead to the subject chemistry in the last year of the level ISCED 2 and in the level ISCED 3 with 2 theoretical and one laboratory lesson per week. More detailed information about the atomic electron shell; atomic electronegativity and type of created bonds are the basic knowledge on this level. Very important themes are creation of the molecule geometry of simple inorganic and organic compounds. Supporting programs for molecule image creation can be found as freeware in internet in example ETC Educhem. Discussions about possible electron shell changes induced by another particle interaction are background for the chemical reaction image. It is the time to learn and accept the chemical language (formulas and names of compounds, description of chemical reactions by equations) in this state of knowledge, not sooner. The last chapter of the basic knowledge content is chemical reaction inception condition, so thermodynamics, kinetics and thermic of chemical reactions. Chemical reactions are explained and described according to the knowledge of chemical bonds. Explanation comes out of the exchange of particles between reactants, the possibility of chemical bond change etc.
At last there is the application the chapters of substance structure, atomic structure, chemical bond creation, chemical reaction inception conditions and chemical reaction progress, which are the tasks of inorganic and organic daily chemistry as well as interesting facts in biochemistry.

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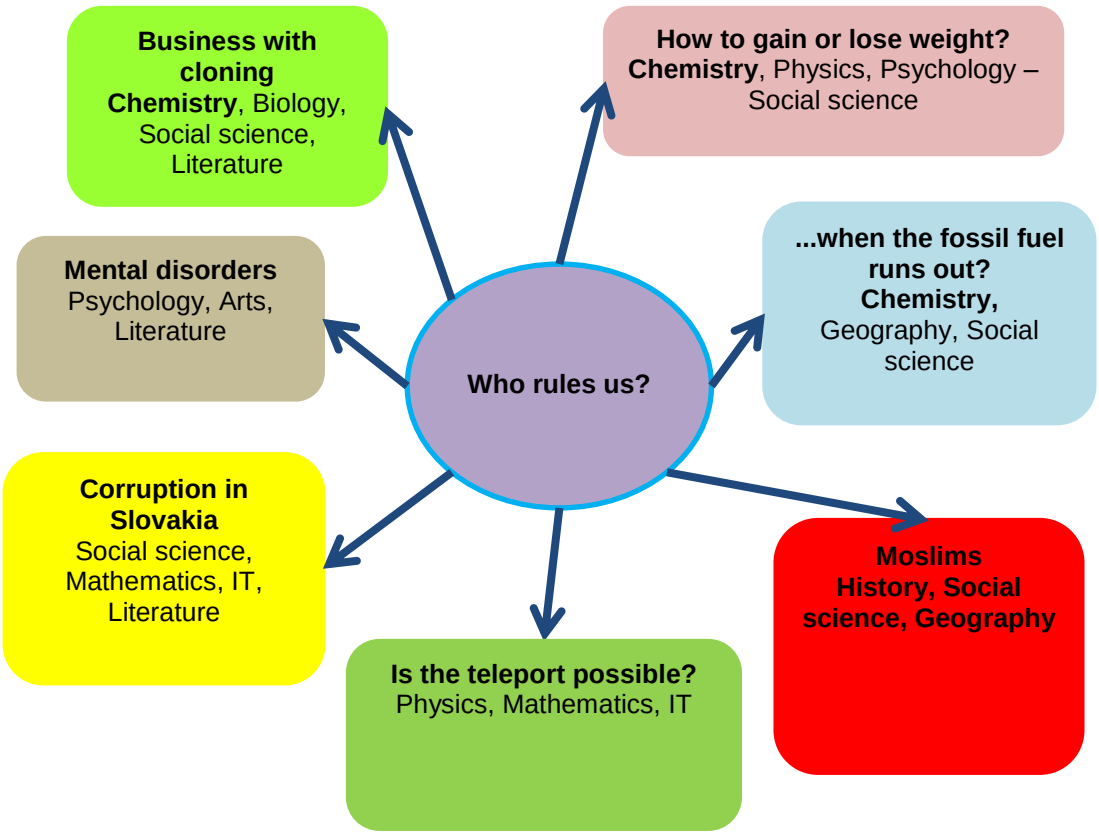
3.2 Integration

Integration of natural sciences subjects could be explained on the Socrates' dialogue on the theme of Mpemb's phenomenon and or ITE themes [9].



3.3 Training of the key competencies

We try to motivate student to effectively obtain the knowledge about nature and natural processes by training of the key competencies [10, 11, 12], such as using the logical operation to

- analyze whole entity and synthetize into the whole entity e.g. theme periodic system of elements
- understand of information serried text in chemical formulas and equations themes
- understand the process described by algorithm and describe the process by algorithm (preparation of experiment)
- recognize of causal inaccuracy and error, e.g. by distractors in the test exercise:
  Chemical properties of the elements are determined by:
  a) Position of the element in the periodic table
  b) Valence sphere of the element and its electronegativity
  c) Position of the element in the period of the Periodic table
  d) Number of electrons in the atom
- express the thought precisely e.g.:

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"Physical properties of metals are consequence of

a) Chemical bond between atoms
b) Crystal lattice between atoms"

- Think divergently – offering the choice e.g.: "Consider the possibilities for oxidation-reduction reaction products creation."
- structure the researched field
- organize data set, assort it and hierarchize e.g. atomic structure, Mendeleyev discover of periodic system
- capture the process by sign system, table e.g. chemical formulas and equations
- manipulate with idealized and abstract concept e.g. the shape of electron orbital of concrete atom
- think critically, to recognize original thoughts e.g. to suggest a method for sorting compounds out of composition
- improve the 2D and 3D vision e.g. molecule geometry
- search for solving strategies e.g. to create the molecule geometry
- transfer ideas from situation to another one e.g. to describe the type of chemical reaction for different elements from one group
- overcome standard procedures by innovative ones e.g. to prepare different compounds
- construct logic maps of the whole
- guess the result before proceeding the calculation
- find limits of the solution
- find analogies of the problem
- describe the solution qualitatively as well as quantitatively
- argue own opinion and find counterarguments
- make a complex chain from partial intellectual activities e.g. to derive atomic and molecular characteristics from partial experiments or information
- work in the team

4 Methods of key competencies training

4.1 To be able to learn from experience e.g. experiments in laboratory classes

This competence is used lifelong. It is often misunderstood and replaced by the term "having praxis". Having the praxis does not mean effective learning, the praxis alone does not guarantee flexible learning employee for the employer. Learning from experience contains four steps forming the cycle.

The first step is actual experience, the second step is reflexing the experience, the third step is creating new concept of the problem and the fourth step is planning of the active experiment and again step one: actual experience (from the experiment etc.

The first step: Actual experience can be realistic or substitution of the reality. We create the actual experience by observing the chemical process, work with the case study, role playing, and simulation games in the process of education.

The second step: Reflexing the experience means systematic evaluation of the actual experience, evaluation of own achievement and preparation for it. An advantage can be writing the work (laboratory) diary, where the facts about work are captured as well as own feelings and evaluation of procedures. It has the character of dialogue

The third step: New concept of the problem represents contextualization the experience with the theory. It answers the questions: Why the success was a success? Why the failure was a failure? How could the failure be prevented?

The fourth step: There is summed up and applied knowledge from previous steps in planning new experiment. The plan of next activities is prepared in this step.

Positive side of this method is the fact that mistakes and failures are considered as instruments of learning.

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4.2 To contextualize real facts and organize knowledge of different types and field

Knowledge of person is non-transferable. Only information is transferable. Knowledge is created in the mind of learner as an individual construction. The construction creation depends on most common learning abilities of the person (according to the Bloom taxonomy). Offering space and time for this process leads to the skill of working with the knowledge and recognizing original approaches and ideas. Standard procedures may be overcome by inventive ones if the learner is able to:

a) Structuralize researched field
b) Apply assorting and hierarchy of phenomena, concepts, experiences etc.
c) Apply ideas obtained from one situation to another
d) Describe a process by algorithm
e) Transform the symbols and algorithms of other people into the own ideas of reality
f) Search for solution strategies

4.3 To organize information of different types

Learning is an active process. The base of success is:

- Sufficient motivation
  Being able to motivate students is the pedagogical and psychological art of the teacher. It is successful only in cooperation with whole society mostly with the student's family. The motivation in chemistry is derived from the possibility of experiments. Therefor we prefer experimentation to theorizing.
- Clearly set goals
  Training of this competence is easier by teacher stating following information in the beginning of the class or course. Needed information is: actual object specification in the course, standards (either for content and student's achievement), theme schedule, and the most importantly key competencies trained during the course in actual themes. (Common and legitimate student's questions are: "What is this for? Where will I use this information? Why do I need it?" Training the key competence may be used as adequate motivation agent
- Adequate activity planning and time management
  To master in preparing own work plan is essential competence for whole life. To date the tasks, informing of the exams and evaluations dates, expectation of agreed tools, and the clear plan of each class is helping to learn this. Evaluation dates are helping as well. Teachers actually are not supposed to catch a student in the act of ignorance; they are supposed to give him a possibility to show what he knows and is able to do.
- Self-evaluation of the learning process:
  Student should have time to obtain information about his own learning from teachers as well as from his peers. The theme: Learn how to learn should be essential in planning the content of homeroom classes (e.g. in Slovakia homeroom classes are once per week for each student with his classmates usually used for organizational information). All the learning evaluation data should be mainly in the center of student's attention and secondly of the parents' attention. Adequate evaluation is therefore also verbalizing the evaluation, not only grade the knowledge.
- The next new goal
  Evaluation is meaningful only in further changes. The change should reflex previous mistakes and search the way to achieve the goal

4.4 Ability to solve problems

A task becomes a problem if the solution is not based on memory or automatic repetition of learned steps and procedures or mechanic usage of experience. A problem is a problem if the answer is not known and the path to the answer is not known as well. This situation needs a very learning.

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The first step is definition of the problem. It needs:

- Precisely know the information content in words, pictures, used situations.
  Adequate training is the skill of comprehensive reading of scientific, artistic or technical texts, understanding the rules of communication, dialogue, discussion, task analysis, signs reading information transfer from symbol into the own constructions, process describe by algorithm understanding, ability to create such an algorithm, ability to organize and hierarchize the data set
- Precisely set the question.
  Adequate training is the creation of quiz questions for peers, evaluation of test questions by students, case study, recognition of causative inaccuracy in the information, encourage students in question asking during the class as well as out of the class.

The second step is giving the time to think. Student should learn the way of his thinking and the type of his intelligence. To understand what on level is his realization of logical operation. Does he make intuitive conclusions or he thinks in structures more? Is he able to analyze and/or synthetize? It is adequate to train the result guess, to know own solution strategies, to overcome standard procedures, to find solution limits, to find solutions for analogical problems, to be able to describe the problem qualitatively and quantitatively as well.
The third step is critical thinking. There is a pre-requisite in ability of evaluation, assumption according to criteria, searching for concepts, structure creation, e.g. categorization and argumentation of own opinion, active, precise and deep in problem thinking without stereotypes.
The last step is to have the courage to decide. We train it e.g. in formative tests with the choosing from possibilities answer, if none of the possibilities is absolutely right, but it is possible to choose the best one according to the known criteria. Student has to have limited time for decision, work independently and assert himself. Teacher has to make space for quiet and submissive students as well.

4.5 To be responsible for own learning

Responsibility is the competence required nearly in each job offer. Individualization is a considerable trend of postmodern era. Parents allow their children the process of deciding for themselves in very early age. Unfortunately, the reason for this allowance is a resignation for upbringing their own children many times. The possibility of deciding must go hand in hand with taking the responsibility and stand the consequences, because freedom without responsibility is anarchy. The training of the responsibility for own learning begins in motivation. There has to be clear goal in being in high school. The help with search for this goal is the task for the class teacher e.g. in homeroom classes, discussion clubs etc. as well as other teacher in actual classes. Importantly, student has to become familiar with possible professions (with the help of parents) and types higher education possibilities in the required field as soon as possible. Later on, there comes the possibility to create personal learning project in high school by defining obligatory and satisfactory conditions for successful accomplishment of study. Being responsible for own learning needs clear aiming demand, standards and evaluation of achieving them. This information must be known by student in advance. Teacher can help student in organizing own learning process in choosing subject and specializations (e.g. see Fig.1.). We do not take the process of learning chemistry as an isolated issue of usage student's competencies, but as well as a procedure and training of the student's key competencies for whole and professional life.

5. The Impact of the Project on Successful Experiences

5.1 Workshop

Our slovak workshop about successful experiences was held in Bratislava 26.3.2014, on the workshop participated 12 teachers of chemistry from elementary schools and from high schools participated at this workshop. In comparison with the original group there were three more teachers of chemistry from

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secondary vocational schools in Nitra and Prešov. The workshop started at 8.30 in the morning and ended at 16.00.

Thematically it was divided into two parts:

1. Discussion dedicated to lectures and publications published on the project's web page.
   All the participants discussed to the first topic, during this discussion they appreciated all the lectures and very good outline of publications dedicated to successful experiences in teaching chemistry. The first interesting lecture was from the Czech Republic which provided review of all successful experiences focused on various competitions, activities, portals, Olympiad etc. All teachers appreciated these information mainly because of the fact that many of these activities is done also at Slovakia. Polish lecture was very innovative in the means of tools for better motivation of students towards chemistry. Spanish contribution about cooperative learning was also interesting. Teachers discussed also about interesting Belgian report about use of ICT technologies during teaching chemistry and about digital school. Slovak publications in which were teachers interested were the ones which explained chemistry in unusual way. They discussed mainly about publications as Chemistry and Cooking, Olives in salmonia and fruit in syrup, 3D visualisation types in multimedia applications in science education and New games in chemistry for attractive chemistry education.
2. Current problems in teaching chemistry and natural sciences at Slovak primary and secondary schools

Katarina Javorova from Department of Didactic and in Science presented short output which OECD published few weeks ago results of project PISA – the biggest and the most important international research in the area of measurements of education results, which takes place all over the world. In solving problems Slovak students achieved average result which was 483 points. These results are significantly lower than average results in other OECD countries. Result of Slovak students in mathematical literacy of international study PISA 2012 is under the average of countries which participated in this project. Results similar to Slovak ones reached countries as Norway, Portugal, Italy, Spain, Russian Federation, the United States of America, Lithuania, Sweden and Hungary. From OECD countries only 5 of them reached lower results than Slovak republic – Israel, Greece, Turkey, Chile and Mexico.

Results of Slovak students in natural sciences literacy is under the average of countries of OECD. Results similar to Slovak Republic were reached in Iceland, Dubai (SAE), Israel, Greece and Turkey. Significantly lower results than Slovak republic from OECD countries reached Chile and Mexico.

Results of Slovak students in the fifth cycle of international study PISA are not satisfying. In every studied area, whether it was mathematical, scientific or reading there was a significant decrease in results of Slovak students. It is the first time when results of Slovak students in all three areas are significantly lower than average results of OECD countries. Teachers agreed that the results are alarming and that it is needed to add scientific lessons as well as lessons of mathematics which were lowered in past.

Ministry of Education of Slovak Republic wants to empower teaching of mathematics and scientific subjects, this information appeared in medias on 25.8.2013: According to the proposal of Ministry of Education there should be added lessons of mathematics, biology, physics and chemistry in timetables of students. On the one hand students should spend more time with calculations on the other hand there will be lowered lesson dotation of other subjects. Teachers think that it will be at the expense of foreign languages.

Increase in science lessons at primary and secondary schools. Proposal for chemistry: Elementary schools – from 4 lessons to 5, Secondary schools – from 5 lessons to 6. All teachers discuss about this number of lessons and about new curriculum.

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Published proposal lacks samples of curriculum for 8-year grammar schools and it is not clear what will be and what won't be in the curriculum for elementary schools.
Nowadays the teaching conditions for teaching of scientific subjects got better, thanks to EU projects the school chemical laboratories were newly furnished, classes have new modern technologies (mainly interactive boards). New teaching principles and methods started to be practised – exploratory method, IBSE research conception, project teaching and digital pH – metres became very popular in teaching chemistry (Vernier, IP COACH etc.).
Big discussion was about decision that teachers could share their experiences with students of teaching in combination with chemistry during three semesters (in years 2012 – 2014) within the project *Incubator of innovative teachers of scientific subjects at elementary and secondary schools* (KEGA Project n. 035UK-4/2012). We realised more than 20 professional lectures connected with seminars and workshops for students of Faculty of Science UK. Students were presented experiences from years of pedagogical practice of innovative teachers of elementary and secondary schools.
Initiators of project plan to continue in realisation of professional psycho-pedagogical lectures, seminars, workshops and prepare new activities. They want to make available new trends in chemistry teaching for students of teaching subjects in combination with chemistry and by this way they want to connect theory with practice.
Teachers could share their experiences with teaching of chemistry at elementary and secondary schools at 1. and 2.national conference organised by civic association - Association of chemistry teachers (ZUCH) in February 2013 and 2014. In this programme were presented previews of innovative approaches and particular chemistry lessons, new textbooks for grammar schools were presented and some serious problems which bother teachers were discussed (insufficient dotation for chemistry lessons, school reform and its impact on education, preparation on chemistry Olympiad and work with talented students, chemistry laboratories and their equipment, support of scientific education and how to make teaching of scientific subjects more attractive and etc.).
Teachers at Slovak schools try to make some changes and know how to teach „good" but they need also support from school leadership, municipal offices, National Education Office and mainly from Ministry of Education. It is needed to end the reform, make new curriculum and textbooks, to state what has to be taught (in which year) and let teachers (school) to teach in their way.

Evaluation

Partcipation on the evaluation was followed:
- gender: 13 female
  2 male
- age group: 10: >45
  3: 26-35
  2 :18-25
- teaching/working experience: 7: >15
  2: 0-5
  2:10-15
  4: 5-10
- portal home page: average: 8
- teaching resources: average: 8

- papers section: average – 8,2

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- publication section: average – 8,2
- usability of portal: average - 8,6
- recommendation the School Inclusion Portal to other colleagues/friends: 14

From this evaluation is clear that teachers and expert are satisfied with section about successful experiences. This section is very useful for the most of them as source of new information and approaches from other countries in the field of the preparation of chemistry teachers.

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