

CHEMISTRY EXPERIMENT IN DISTANCE EDUCATION

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Abstract

In compliance with the National Programme for Development of Education in the Czech Republic and the draft of the Act of Preschool, Primary, Secondary, Higher Secondary and Other Education, a new system of curricular documents for education of pupils between 3 and 19 years is implemented. On the state level, the Ministry of Education, Youth and Sport creates the curricular documents called the Framework Educational Programmes. These documents define the standard educational contents for preschool, primary and secondary school.

The Framework Educational Programme for General Secondary Education emphasizes an appropriation of critical thinking and scientific method of research in science education. As far as chemistry education is concerned, this requirement is naturally realized by the pupil's work on chemistry experiments.

The information and communication technologies (ICT) development provides an opportunity for utilization also in education. The Department of Teaching and Didactics of Chemistry is preparing new secondary school chemistry teachers. We are concerned with usage of the ICT in chemistry education particularly in relation to the chemistry experiment.

Experiment is a vital part of chemistry education, but the science experimental work is not frequently used in distance education or e-learning courses yet. In the contribution presented here we would like to share our experience with extension of distance courses by bringing chemistry experiment to learners. We present interesting examples of experiments used in blended chemistry courses for students at every level of education system as well as in on-line chemistry course for wide population of non-chemists.

Key words: *chemistry experiment, distance education, e-learning.*

Introduction

In consequence of the European Union educational policy expressed in the Lisbon strategy and other documents, Czech Republic declares its own educational conception particularly in the document National Programme for Development of Education in the Czech Republic. On the state level, the Ministry of Education, Youth and Sport creates the curricular documents called the Framework Educational Programmes (FEP) for the development of the key competencies in every school subject and to define the standard educational contents for preschool, primary and secondary school. We are focused on the secondary schools in this paper.

The part of FEP relating to the science educational field (including chemistry) is called "Man and Nature". Specific competencies listed in the "Man and Nature" educational field emphasize the formulation of a science problem and its solving through observation, experimentation and measurement, data processing, modelling of the natural processes, making predictions based on the learned laws of these processes, and use of mathematics and modern technologies (Rámcový vzdělávací program pro gymnázia, 2006).

Reality of chemistry education

Most of the objectives set out in the “Man and Nature” educational field can be realized within the frame of the pupil’s own experimental work. However, many of our chemistry teachers face up several practical obstructions impeding the realization of the modern chemistry education described above. Most frequent obstructions are: lack of time for the regular experimental work, lack of funds for the chemicals and tools purchase, insufficiently equipped or even missing laboratories, and the safety regulations restricting the pupils work with the chemicals. Another problem stems from the insufficient preparation of new chemistry teachers, which is sometimes oriented too theoretically. Teachers rising from this type of education avoid chemistry experiments in their lessons.

Chemistry experiment in distance education

Distance courses are difficult to include in the primary and secondary school education. The education is based on the attendance and face-to-face lessons and does not allow organizing the courses in the distance form. However, distance education elements can be freely implemented into the presence education. Czech secondary schools have sufficient technical equipment to support the distance education in general. Computer laboratories connected to Internet are available for students and the computer literacy of both students and teachers is good enough.

In most cases, the distance courses in science education are based on the work with text, information and theoretical thinking, because the practical distance courses are hardly feasible in general. As far as chemistry is concerned, the distance education based on experimental work has its own specific difficulties: handling with hardly available and dangerous substances and lack of proper glass and equipment. There is often insecurity regarding the accuracy of both procedure and results, too.

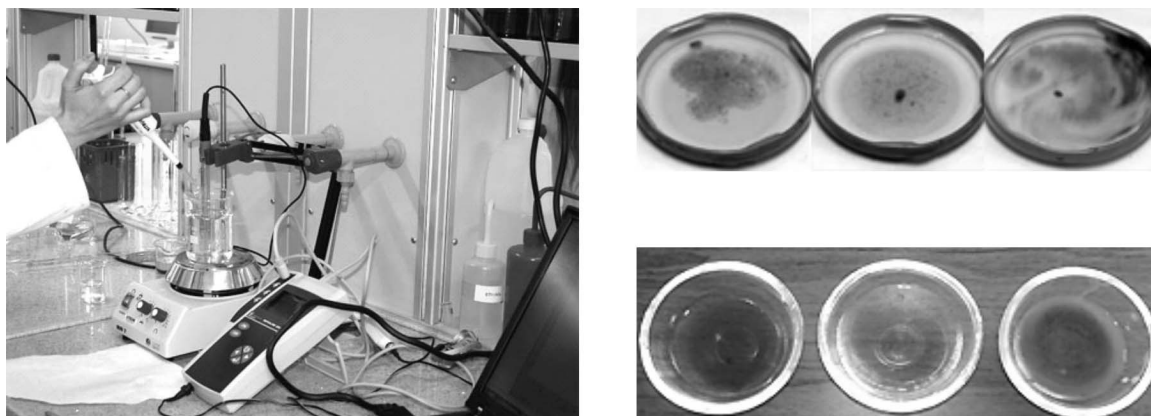
But recently the development of information and communication technologies and the increasing Internet availability enable the e-learning courses based on the learner’s own experimental work. These technologies allow providing of photos and short videos with the instruction, or faster and easier communication between tutor and learner and thereby the faster problems solving. Remaining difficulties connected with practicability of experiments can be solved by the proper adaptation of the original laboratory version.

Home chemistry experiment

Concerning the specifics of distance education, we can lay following demands on the chemistry experiment: handling with simple equipment and available chemicals void of dangerous properties, and sufficient motivation effect. Learning by experimental work requires an experiment which explores a system complex enough to allow creating several hypotheses, but not so much complex that the hypotheses verification is impossible; which meets other sciences, their knowledge and methods, and also the situations of daily life; and which can be set as a problem task open to the heuristic approach.

We suppose that the experimentation with the natural substances and readily available materials (Figure 1) in itself contributes to meeting the demands set above. Food, plants or household equipment are very well available, safe and inexpensive “chemicals”, using them means a strong motivation due to their connection with daily life, and they can be explored also from the biology or physics point of view. Natural materials such as food or plants are of uncertain composition (for pupils), which allows creating a number of hypotheses. In this case pupils understand the need of hypotheses verification naturally – it leads them to the scientific method of thinking and research. However, the uncertain composition of the used materials brings one disadvantage: the presence of many other substances can complicate even a well-known and simple chemical reaction.

Many of “traditional” chemistry experiments can be modified by substitution of the respective pure chemical substance by its natural source or an alternative available at home, simplification of laboratory procedures (an electric kettle or a microwave instead of a laboratory burner) and using other off-hand tools.



**Figure 1. Laboratory chemistry experiment vs. home chemistry experiment
Acid-base titration with pH electrode vs. elderberries and bilberries as an
acid-base indicator.**

Working with natural and readily available materials can be integrated first of all into the education of biochemistry and chemistry of natural substances (proteins, fats, sugars, enzymes, dyes etc.), but it can also upgrade the education of general and physical chemistry (acid-base theory, pH indicators, catalysis, electrochemistry), and both organic and inorganic chemistry.

Of course it is necessary to test each new experiment thoroughly with a detailed documentation. Some materials decay and the desired chemical components can be decomposed after a short time. Also the principles of the observed chemical reactions should be carefully examined, verified and confronted with a scientific literature.

Experiences with the utilization of chemistry experiments in distance education

Safe and modest chemistry experiments modified in a way described above are suitable not only for a “kitchen realization” within the distance education courses, but also for school science education, especially for schools without chemistry laboratories, and for varied science hobby-activities such as summer camps or hobby courses.

Chemistry education in secondary schools

The courses based on home chemistry experiments cannot cover systematically the scope of school chemistry education, but they can support the face-to-face learning on every type of school. Home experiments can be implemented into the routine chemistry education in form of homework or extended activity for interested pupils.

For example, the laboratory work in electrochemistry was set as homework in a lower class (14-year-old students) of private secondary school. Students created a simple galvanic cell (Figure 2) and an electrolyser from the obtained material (wires, pieces of metals and diode) and explored their behavior and properties. This work was a heuristic preparation for the following first lesson of electrochemistry (Böhmová, 2006)



Figure 2. Photo documentation of electrochemistry homework – galvanic cell.

Students appreciated ample time to work and the interesting topic of homework, but they missed hardly the presence of the teacher. This can be set as a general rule - younger children are often insecure, they have to be led with a proper work sheet and the experiment cannot be too complicated. On the contrary, older students regard highly the possibility of their own planning (Böhmová, 2006)

Pre-gradual and further education of chemistry teachers

“Education in organic and practical chemistry” is a distance chemistry course in the “Moodle” project of Charles University in Prague, designed for the undergraduate students of didactics of chemistry. It involves some problem tasks for the knowledge fixation and as an inspiration for their own teaching practice. (Šulcová, 2006)

“Current conception of the experimental education of chemistry at primary and secondary schools” is a semestral chemistry course of lifelong education in the JPD3 ESF and Prague municipal council project. It is designed for the chemistry teachers and it is realized at the Department of Teaching and Didactics of Chemistry, Faculty of Science, Charles University in Prague. The e-learning support of this course provides many tens of chemistry experiments instructions including the result photos (Figure 3). Two of the lessons are directly focused on creating and using home chemistry experiments (Šulcová, Böhmová, Martínek, 2006)



Figure 3. Home chemistry experiments with food (biuret test) Courses of chemistry teachers' further education.

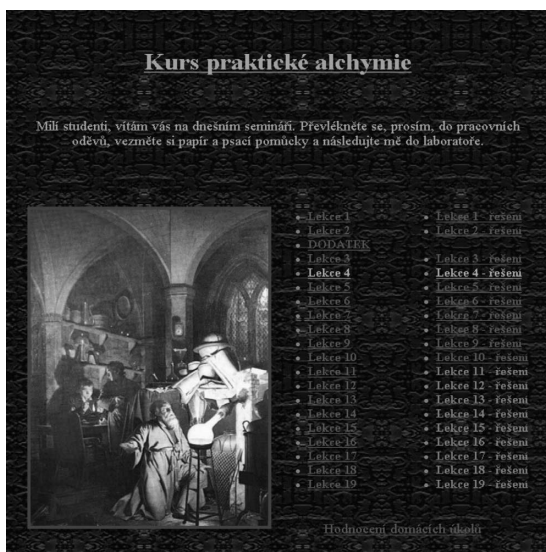
Hobby chemistry courses

Figure 4. Home page of the “Course in Practical Alchemy” with the list of lessons and their solutions.

“Course in Practical Alchemy” (Böhmová, 2006) is a chemistry e-learning course designed for the wide range of non-chemists which leads the learners to the better understanding of the selected topics of chemistry and raises their interest in chemistry and science through their own experimental work. The course consists of nineteen lessons – one lesson per fortnight. Each lesson contains instruction for three or more home chemistry experiments on a given subject. Solutions based on learners’ reports and photo documentation (Figure 5) and explaining the theoretical principles of observed phenomena are drawn up for each of the lessons. The course is realized within the frame of a big youth Internet community oriented on science fiction and fantasy and it is based on witchcraft stories popular among young people - Harry Potter books by J. R. Rowling, etc. Discussion forum, web pages (on the URL www.prskavec.mysteria.cz, Figure 4) and e-mail are used as communication tools. (Böhmová, Šulcová, 2006)

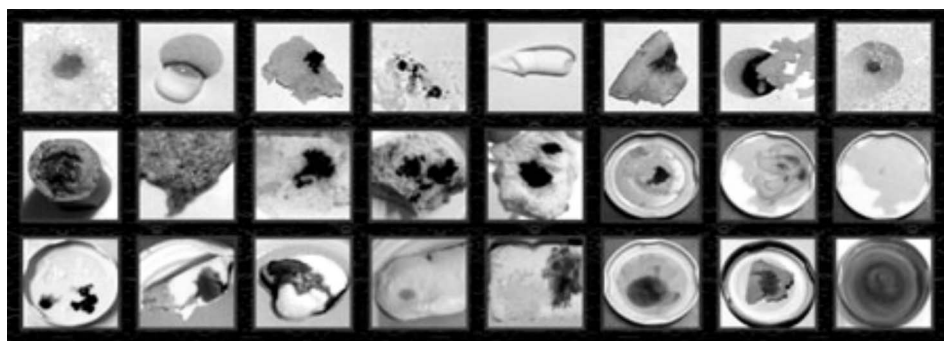


Figure 5. Photo documentation of home chemistry experiment – starch test by the learners of the on-line “Course in Practical Alchemy”.

The course was evaluated by 20 learners in the annual questionnaire. Interesting and surprising content connected with daily life, and carefully prepared instructions were appreciated. As a negative it was stated that the lessons are time-consuming. Compared with other on-line hobby courses realized for the same youth community, the „Course in Practical Alchemy“ was higher than average in every characteristic: entertainment, contribution to daily life, quality of lessons, communication with tutor, objectivity of evaluation and general level of the course (Böhmová, 2006).

Conclusion

Our aim is to provide an all-round and high-quality preparation for the future teachers of chemistry, to develop their creativity and science and computer literacy and to prepare them for the real life situations. Although the chemistry education in Czech primary and secondary schools rather resists the implementation of home chemistry experiments in the distance form, we endeavour to lead our future chemistry teachers to creative and practical working with the knowledge gained. This competence is important not only in the creating of new forms and methods of chemistry education, but it is applicable generally.

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