

“Feel the Chemistry with Chemistry” Successful Experiences in Teaching and Learning Chemistry in Poland

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Abstract

The paper presents the main objectives of the Polish chemistry education and training and points out specific national problems which still require solving. In the context, the authors consider several case studies of successful educational initiatives, projects, or even lesson plans whose main objective was to create new quality in teaching and promoting chemistry, as science in the contemporary world. The paper concentrates on best practices in the field of students' motivation and education, teacher training and involvement of industry in the two above. The document pays special attention to relations between knowledge acquisition and learning practical skills, between knowledge and work or practice, as well as on finding the relations and their application as a great challenge of all modern teaching curricula. As a conclusion the authors announce a change of priorities in the increasing level of effectiveness of educational programs, from developing technical infrastructures and creating new tools to the application of the existing ones with higher level of creativity, commitment and expertise. The paper also tackles the application of online, innovative educational initiatives and involvement of the chemical industry sector in the promotion of scientific subjects among young people in order to make them aware of the potentials of scientific career development.

1. Introduction

1.1 Priorities of Teaching Chemistry in Polish schools

The most common assumption of all educational programs, curricula and syllabuses implemented in Poland is to point out relations between chemistry as science and the environment surrounding us. The main objective of these educational initiatives should be oriented for stimulating students' natural curiosity about the surrounding world of substances and their transformations, and as a consequence, gaining useful knowledge of everyday life. Key competencies are mentioned here: reading - the ability to understand, use and process texts on chemistry content, the ability to search, select and critically analyse the gathered information, the ability of mathematical reasoning, scientific thinking understood as the ability to use scientific knowledge in order to identify and solve problems, and make conclusions based on empirical observations concerning nature. Another crucial competency is the ability to use ICT efficiently and finally, social skills enabling young people to teamwork or lead a group. Regarding the aims of education, these educational programs focus their attention on the development of students' beliefs that understanding of chemistry is based on experiments, which should encourage the student to make observations and formulate relevant conclusions from the experiments performed, stimulating people to learn chemistry as a science which is useful in practice and pointing out a ubiquity of chemistry in the human life, pointing out relations between chemical analysis, structure and properties of substances and their applications, developing skills of expressing chemical compounds and equations using chemical formulas formally and the use of a chemical nomenclature and finally,

increasing ecological and pro-health awareness [KMB]. These priorities are not unique comparing them to similar recommendations applied in other EU countries. The specificity of Poland in this context consists in the economic situation of the country, resulting in a special emphasis on practical skills, ready to use and implement on the labour market without increased effort of employers in the education and training of new employees. Another reason is a relatively small expenditure on education, especially the expenditure on the technical infrastructure of teaching. In addition, creating the possibility of a unimpeded profiling of the learning at secondary level for the students makes their choices based on the current situation on the labor market in the early stages of education. Crisis in industrial production decreased young people's motivation to choose chemistry as a subject of their majors and specialisations. In the light of the aforementioned prerequisites, all forms of motivation for learning chemistry are particularly important, especially that they are based on the relationship between chemistry and industry, direct applications of chemistry and - due to the unflagging interest of medical science in the later stages of education - chemistry in medicine and health prevention education. This is consistent with trends exhibited, both in higher education and the structure of the labor market in other EU countries [CECDE] [MM] .

2. Best practices in students' motivation

2.1 Potentials of integrated Educational Campains

From the point of view of the chemical plant PKN ORLEN SA, one of the largest oil companies in Europe, chemistry is the most important course implemented at all levels of education. Many people who found employment in the company, were graduates of chemical studies and as statistics reveal there is still high demand for well-educated and trained graduates of chemistry profile. The aim of the educational programme "*Poczuj chemie*" was to educate and stimulate a new generation of young chemists, who want to build their future on chemistry, the future in both educational and professional aspects. Based on previous experiences of ORLEN - which has pursued educational programs such as "*Lekcja chemii*" - it creates a new quality educational system, which is expected to attract students to chemistry after hours spent in school [GS]. The foundation of the project was a new language of communication, developed on the base of a previous project supported by PKN ORLEN "*Lekcja chemii*" . It was attended by 40,000 students whose interaction with that project allowed its authors to gather experiences for the new initiative. The authors emphasize that feedback between producers and consumers of the teaching content had a key role in the creation of a new quality. They also used popular media and technologies. The keynote of the project was a spectacular side of chemistry , with not-dominant formal description. The chemical portal *poczujchemie.pl*, the main result of the project, as interactive, dynamic, with a modern graphic design, stands out from the other solutions of this type. Of course, there are also presentations of experiences and interactive learning tools. The novelty consists in competitions with prizes (including non-virtual), often organized by the exchange of multimedia records of chemical experiences. The pioneer feature is also a formula for direct contact of schools with 'mobile' experts, 'experts on the road' who promote not only the chemistry as it is, but also through loosely related activities available through the portal [WPC]. The portal gathered many experts who interact with users on blogs and forums. Many of these experts are PKN ORLEN scholars who stand out not only due to their knowledge, but also due to pro-social attitudes. The portal has an additional interface for mobile devices. In this version of the site the authors abandon a typical professional hierarchy, known from other information portals for a loose convention of the computer game. Experiences with this form of knowledge transfer seem very interesting, but lack any evaluation of the type of learning, beyond the clearly positive assessment of users in terms of providing entertainment, does not allow to formulate any conclusions, yet. After a year and a half in operation,

the portal has gathered more than 110,000 unique users, and 4500 of fully registered, who fulfilled all the authentication procedures. Among them we can find students from Polish partner schools of the project *Chemistry Is All Around Us - Network*. One of the measures of popularity of this web service is the submission of several hundred movies to two competitions on the presentation of the movie about pupils' own chemical experiments.

2.2 Online materials

“Baza Narzędzi Dydaktycznych” is the best example of an online database of resources for both teaching and learning chemistry in Poland. It offers a variety of tasks within the subject of chemistry, physics, mathematics and humanities with comments and answer keys. The intention of this initiative was to support teachers who endeavor to make teaching and learning chemistry at school more interesting. The authors of the portal were encouraged and inspired by the results of recent studies indicating that young people are more likely to go to school today than five years ago. New core curriculum of general education tends to go from memory learning, „learning for the test”, the repetition of algorithms and „chaining dates.” The initiative wants to promote the new systematic approach towards teaching critical thinking, reasoning, and logical thinking skills. The whole portal offers proven ideas and sets of tasks in chemistry and physics which can be useful for conducting interesting classes in these subjects. The portal authors invite educators, teachers, and teacher trainers to add to the tasks discussed. The portal's main objective is to serve as a source of inspiration not only for teachers but also for students across disciplines and parents who want better education for their children; education which is more attractive for them, awakening their imagination and ability to think independently. The authors of the portal invite all enthusiasts of education to enrich comments, add suggestions, as well as ideas for new tasks, lesson plans and other teaching tools. Currently, the portal's content focuses on the lower-secondary school level core curriculum. In the future, it will be expanded for upper-secondary school students and vocational school students. As it was mentioned above, all the presented ideas and tasks have been created by teachers and scientists involved in the work on the new core curriculum. The collection of tasks, assignments and experiments can help teachers in the development of pupils' skills defined in the general and specific requirements of the core curriculum for the third stage of education. All the materials in this database in terms of content and form are based on the printed version of the booklet, and are fully compatible with all the requirements prepared by the Polish Central Examination Commission. The new core curriculum includes both general and specific requirements for teaching and learning. Specific requirements apply to the content of education, including mastering certain kinds of information and knowledge, and general requirements apply generally to complex skills, often within the cross-curricular framework. These refer to reasoning and argumentation, exploration, exploitation and creation of information, knowledge of research methods of the natural sciences development. It should be emphasized that the general requirements shall take precedence in relation to specific, and some complex skills, such as those concerning research methodologies which are stored only in the general requirements. All the suggested material and tasks relate to the requirements of both types, and comments posted facilitate their interpretation. The authors of the tasks are teachers and researchers, working with the Institute for Educational Research. The database of the material is gradually enriched and updated.

2.3 Akademia Uczniowska - Experiments in chemistry

After implementation of the core curriculum requirements into lower-secondary school education, each student at this level of education is supposed to realize the so called “projekt gimnazjalny” in a given subject of his or her choice. Below we would like to discuss *“Projekt Gimnazjalny Akademii*

Uczniowskiej” an online database full of lesson plans and ready-to-implement solutions based on the conduct of experiments, observations, learning games and activities with the problematic question. Various scenarios of projects equipped with tailored lesson plans were developed by teachers and students and validated by experts as a good practice of science teaching in the modern Polish classroom. Teachers, actively involved in the project, participated in the *Akademia uczniowska* course on "experimentation and mutual learning". All lesson plans collected in the database include the following issues formulated by the students: needs analysis, research questions, hypotheses, description of the students' experiences, planned and carried out projects designed Mutual Learning, educational games and evaluation.

Maria Bednarek, a chemistry teacher, from lower-secondary school in Brzeziny agreed to supervise a lower-secondary school project on *'How to impress and fascinate myself and colleagues with chemistry and chemical experimentation?'* The project's goal was not only to increase the interest in chemistry among young pupils, but also to teach them how to safely experiment and how to document and present chemical experiments to the audience. The project was an initiative of "purely" experimental value in agreement with the statement that 'learning by doing' is the most important way of learning chemistry. The entire project was conceived as a set of simple but impressive experiments, with hands-on activities that were presented "live" and which showed beautifully, that chemistry can be "cool" and, what is more, it can be interesting, both for those performing the experiments and for the spectators. The main objective of the project was to encourage pupils to learn the subject of chemistry at school in an innovative and motivating way. At the initial phase of the project realization, a concise contract has been drawn up between students and the teacher on the schedule of activities and implementation of tasks. Jointly with the teacher students developed the appointments, subject of the problem and specific questions. Then the experiments in the laboratory were carried out (5 teaching hours) and thoroughly documented by the students. On completion of the practical part students created a PowerPoint presentation in order to visualize the results of their work. Finally evaluation of the project work was preformed and the results discussed.

2.4 Shows, experiments and lectures

Higher education institutions in Poland are quite active in promoting learning and teaching chemistry in an interesting and innovative way. In the current academic year, Jagiellonian University in Cracow Department of Chemistry invites pupils and students of secondary schools to participate in *Meetings with interesting chemistry, Cryogenic Demonstrations, Workshops for high school graduates - "Last call before Matura exam" ; Lectures on "Chemistry has many names"*. The above listed are only a few among many exciting initiatives for young people, whose main objective is to increase awareness of the society and promote better comprehension of science oriented subjects.

3 Best practices in pre-service and in-service teacher training

3.1 The role of Higher Education Institutions – Innovative online teaching

The idea of new ways of teaching is to create conditions for rapid and sustained absorption of knowledge and facilitating access to educational materials at the same time more attractive rates. The e-learning courses give such perspectives, allowing teachers to adjust the pace of the classes to student's individual needs and develop contents that easily reach the student. Undeniable advantage of e-learning is the practical abolition of restrictions on time and place of study, which allows you to work both at home and at the university, and also allows for remote participation in courses during popular programs of foreign exchange. The introduction of e - checks gives also the possibility of an efficient, objective and timely assessment of a large number of students. The paragraph below

presents a variety of solutions used in the electronic supporting teaching at the Faculty of Chemistry, Technical University of Wrocław. Currently, one of the leaders in the implementation of solutions related to e-learning of the university's Department of Chemistry. Four years after the start of the Portal of Electronic Support Teaching at the Faculty of Chemistry there have been developed over 70 courses that are available through Moodle. The presented ideas of e-learning reflect different concepts of electronic teaching support used in teaching portal available courses - ranging from the insertion of "static" instructions and tasks for students, through to electronic exams designed to test students' knowledge.

The majority of the in-service training for teachers of Chemistry in Poland is organized on the voluntary basis. There are no obligatory requirements for teachers meet and courses to complete in order to teach chemistry in Polish schools. Their university education expanded with practical teaching component is the only must have. Teachers engage in the development of their careers on their own and they care about their professional improvement due to the general directives of teacher training. Trainings, workshops and seminars participation and attendance are only a part of their professional activity. In order to advance and climb their professional ladder they must follow general 4 level teacher development path from novice teachers to the diploma ones. A series of regional and local institutions offer trainings of various kinds for practising teachers, which is a great opportunity to comply with Ministerial requirements and hold a higher teaching degree. For example the Regional In-Service Teacher Training Centre in Lodz is a public educational institution. The main aim of the centre's work is to support the education environment in achieving aims of the educational reform and in aspiration for proqualitative changes. The centre is also seriously engaged in the integration process of local educational community. It offers over 170 various forms of training for school principals, teachers and local government representatives who are involved in issues of education. The main subjects of their training courses concern: quality in education, teaching problems, planning and documentation of professional development and advancement of teachers, information technology, European education, pedagogical skills and languages. The Regional In-service Teacher Training Centre is engaged in application of new pedagogical methods with the use of IT. It edits methodological materials for teachers and quarterly The Educational Review. The Centre co-operates with: Technical University of Lodz; University of Lodz, The Academy of Humanities and Economics in Lodz, The Academy of International Relations and the University of Computer Sciences and Skills. Each region of Poland has a similar institution dedicated to teacher development. A series of publishing houses oriented for scientific subjects such as ZAMKOR offer online portals for both students and teachers to help the first raise their interest in the subject, whereas the latter gain extra qualifications and skills in order to teacher in a more interesting and technologically advanced way. Teachers can also select from many high quality offers among which is the one of the Centre for Education Development (CED). It was established on 1 January 2010, as the result of merger of National In-Service Teacher Training Centre and Methodological Centre of Psychological-Pedagogical Counselling. CED is a national teacher training institution. The Centre objectives include actions for quality assurance in education, particularly through supporting schools and educational institutions in carrying out their statutory tasks and support of changes in the system of education in the field of teachers' professional development. The new Polish science curriculum was launched in the 2008 and currently implemented in upper secondary schools. The new general objectives of education, and students' key competences that should be developed during science classes were defined in that document. Presented competences are in line with competences that might be developed by *Inquiry Based Science Education* (IBSE). IBSE is currently a popular instructional method in many countries and it is being strongly promoted by European Union. In the article the role of IBSE in the new Polish

science curriculum is described and related to the method of 'Independent Investigation to Acquire Knowledge' that was formerly known in the national pedagogy.

3.2 Language training

After a thorough needs analysis of the Polish educational market requirements, one can point out to a well-trained and educated teacher equipped with at least one language command. Without any doubt pre-service teacher training in Poland should focus on the foreign language learning and teaching. A chemistry teacher with a high command of English language skills is a must in a modern and innovative classroom, in which access to online resources is a regular procedure, performed daily. *English for Chemistry: Film Bank* is a non-profit project, aiming to provide materials for teaching English for Specific Purposes at B2 level in accordance with the Common European Framework of Reference to the students of the Faculty of Chemistry at the Jagiellonian University in Kraków. The project was conducted in the academic year 2010/11 by third year students of this faculty under the supervision of Dorota Klimek, a teacher of English at the Jagiellonian Language Centre. The distinguishing feature of this project was the involvement of students from the Faculty of Chemistry of the B2 level in the process of the development of multimedia materials on specialized issues: selection of films from the public Internet resources and creation of the language tasks and exercises. The final product of the project was a website created for educational purposes only. The film bank includes a set of listening comprehension exercises based on films concerning a variety of chemistry subjects, carefully selected from the multitude of materials available on the Internet. The films are accompanied by a follow-up section, consisting of complementary reading and vocabulary exercises. The materials can be used in the classroom and for self-study purposes alike. The files are also available as printable pdfs.

Jagiellonian University is also promoting scientific development of its lecturers, students and graduates. *Niedziatki magazine*, edited by the staff of the Department of Chemistry Teaching, is designed for teachers of science, especially chemistry, as well as for students interested in these subjects. The aim of this quarterly journal is to promote chemistry and its achievements, information and discussion about the problems of teaching science, information about the activities of the Department of Chemistry Teaching at Jagiellonian University. In 1998, the magazine received the recommendation of the Polish Chemical Society and has been recognized as the publication recommended for school use. The authors of the articles in *Niedziatki* are primarily researchers and teachers, but also students of chemical departments. The magazine publishes popular articles devoted to teaching science, particularly teaching chemistry, history of chemistry etc. Furthermore, it contains updates on the activities of the Department of Teaching Chemistry - information on teaching sessions for teachers, competitions for students of secondary schools, open days of the Faculty of Chemistry, Department of Chemistry studies, including postgraduate studies.

4. Best practices in chemical industry – Impact on education and training

Chemical industry has a great impact on teaching and learning chemistry in Poland. Let us briefly analyze the Chemical Plant "POLICE S.A." a fertilizer and chemical industry representative. The company was founded in 1969 and currently it employs more than 2,000 people. When selecting the partner institutions Chemical Plant is primarily guided by the institution's educational profile. The target group of the company is: secondary school students with a chemical profile. Students after a minimum of second year of study, especially technical universities of such faculties as: chemical and process engineering, chemical technology, environmental protection, environmental engineering, management and production engineering, transportation, logistics, engineering, mechanical engineering,

automation, robotics, electrical engineering, power engineering. Chemical Plant "Police" co-operates with schools and universities from the West Pomeranian region, which include: University of Szczecin, West Pomeranian University of Technology, Maritime Academy, and West Pomeranian Business School. Among many partner universities are also Poznan University of Technology, Warsaw University and Warsaw School of Economics. Cooperation with schools and universities is based on long-term contracts on the basis of organized programs and internships in the company. In addition, some universities, for example, West Pomeranian University of Technology, the Company entered into and executed a framework agreement for the annual adoption of best students to practice. School of Economics has organized a company dedicated editing postgraduate studies in management. For their technologists Chemical Plant "Police" start from 2013, on a similar basis as the SGH degree in chemical and process engineering, which led Warsaw University of Technology. In addition, in order to raise the competence of controlling, University of Szczecin the company organizes special edition of postgraduate study in this field. Cooperation with educational institutions has been permanently included in the activities of the Chemical Plant "Police" and is an important tool for its branding strategy - strengthening the positive image of the Company, both in the local community as well as across the country.

Conclusions

The case studies of implementation of comprehensive programs to support teaching chemistry presented in this document provide a view of the trend in the use of modern and innovative solutions in the context of the Polish education system . The main conclusion seems to be the assertion that the period in which the focus was on developing new, innovative methods slowly evolves into the consumption of these innovations, with the particular emphasis on the creation of the basis of already implemented prototypes of new teaching resources in other areas of chemistry, ICT support for virtualization experiments and e-learning. The great emphasis is placed on companies and industry cooperation, which in addition to the natural profit in the form of exchange of experiences has also a marketing aspect. It proves the fact that chemistry, as a branch of science and a field of study, is a good choice in terms of further education and work careers. The role of the Project Chemistry Is All Around Us - Network is undeniably useful in this regard. Providing solutions to support the education process remains the main task of the project , but it seems that in the future the strongest accents will be moved to the cooperation between the partners from industry and raising the qualifications of the teachers through the use of the collected tools and materials within the project's operation.

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