SUCCESSFUL CHEMICAL EDUCATION FOR NON-CHEMISTS: HOW MIGHT IT BE ACHIEVED

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Abstract

The aim of this study was to find an effective model of teaching chemistry for would-be engineers. It was shown that incorporation of "professional", "ecological" and "real-world" components to the classical general chemistry course and including practical engineering tasks to laboratory improves the quality of engineering education and makes the process of teaching more interesting for the students.

Key words: chemistry in engineering education, content of education, curriculum.

The background and the problem

The importance of chemical education for future technicians is undoubted. Knowing about chemistry is necessary not only because science affects so much of everyday activity but studying chemistry helps prepare students for life in advanced technological society and to achieve their career aspiration.

Modern system of technical education in Belarus was formed under the strong influence of soviet high school model. General chemistry course was obligate for students of technical specialties in former Soviet Union since 1921. But today's concept of chemical education for technicians is a heritage of program performed by Luchinsky in 1974. The main idea of this concept is to separate content of general chemistry course into two parts: theoretical and practical, adopted to the needs of future specialty of students (Khaletski & Basov, 2006).

Ministry of education of the Republic of Belarus developed in 1999 the first generation of State Educational Standards to describe demand to curriculum including general chemistry course. This year the second revised generation of standards will be prepared. These standards give only the framework (not detailed) content of chemical education and allow lecturer to find own way to students minds.

The problems and difficulties of teaching chemistry for future technicians are common. Firstly, starting levels of students vary greatly. Unfortunately, many of them have a low school background in chemistry. Secondly, students have a lack of motivation to study chemistry because they don't understand the impact of knowledge of chemistry on their future professional practice. Thirdly, it is necessary for lecturer to deliver a large volume of knowledge within a short period of time.

The purpose of this study was to find an effective model of successful chemical education for students of technical specialities.

Review of the literature

The aim of review of the relevant literature was to analyze different approaches to organization of chemical education for future technicians world-wide and especially in post-soviet countries. It has been found that now exist three models of chemical education in technical universities (Khaletski & Vasilevskaya, 2007):

1) "Classical" general chemistry course. The structure of these courses is similar and can vary a little in different countries (stoichiometry, atomic structure and bonding, thermodynamic, kinetics, equilibrium, solutions, ionic reactions, electrochemistry, corrosion, polymeric materials). This model of chemical curriculum is spread at a great scale in Belarus, Russia, Ukraine, Spain, Argentina etc.

2) Special chemistry courses fully adopted for needs of future specialty of students. For example "Chemistry of Building Materials" is offered for future civil engineers in technical universities in Germany and Bulgaria.

3) Lack of chemistry courses. But in these rare cases the chemical items are incorporated in relative courses like "Material Science".

In engineering education in some technical universities in USA since last 1980s started work on integrated curricula with the aim to build links between distinct disciplines. Usually integrated courses include chemistry, math, physics and engineering (Froud & Ohland, 2005).

Unfortunately not much research exists on content selection to curriculum for technical non-chemist specialties. Since the last 1970th this problem is discussed in not numerous publications. Emphasis on practical tasks required in future professional activity of students is obvious (Kybett, 1982; Sidorenko & Zaglyadimova, 1983; Juhl, 1996). In addition Sviridov (1996) considered that priority in content should have items required to form understanding chemistry like integral science. Gillespie (1991) remarked that general chemistry course is often oversized and should be simplified for better understanding by the students.

The requirement of largest improvement in students' knowledge in the area of environmental protection was declined by Azapagic et al. (2005).

The research setting

The research was held in State Technical University of Brest (BSTU) since 1995. According to the study system in BSTU the studies lasts five academic years (ten six-months terms – semesters). Chemistry is obligatory subject for would-be engineers (civil, machine-building, water-supply) and is introduced to syllabus of first academic year.

In the beginning of research the content of lectures was revised. To the classical general chemistry course three components (*professional*, *ecological* and *real world*) were incorporated. Professional component has to convince the students that knowledge of chemistry will be necessary for their career. Ecological component helps to understand the vital role of chemistry in environment protection. And real-world component not only makes the process of teaching interesting and enjoyable but also equips students to decision-making process in their everyday life. Fig.1 represents example how can it be achieved in theme "Catalysts and inhibitors".

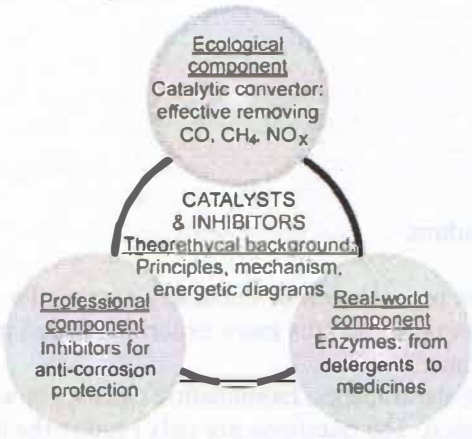

Figure 1. The schematic representation of theme "Catalysts and inhibitors" including professional, ecological and real world components.

At the second stage laboratory references book were revised to include some professionally oriented projects, for example "Comparison of corrosion process of tin-plated and zinc-plated steel", "Making propyleneglycol-based antifreeze", etc. Also special tasks introducing the main principles of carrying out calculation in technical practice were developed.

Presentation and the discussion of the results

In 2006–2007 academic year 101 students (four groups) of Mechanical department of BSTU took part in research. Chemistry course for these students consists of 84 hours (50 hours lectures + 34 hours labs). At the end of semester a small "essay" was proposed for students. They were asked for three questions:

1) Have you changed your opinion about chemistry during semester?
2) Which themes do you find interesting? Boring and difficult?
3) What would you like to change in organization of chemistry course in university?

The writing of "essay" was anonymous and of students' own accord.

57 essays were got. 10 students marked that they didn't changed their opinion to chemistry. They knew that chemistry is important and interesting science even before university. But to the big surprise for the authors others (47 students) marked that their opinion about chemistry was completely changed:

"In the beginning I was absolutely convinced that chemistry is not necessary for engineers. But now I understand that I was wrong",

"I never thought that chemistry could be so interesting and fascinating",

"Yes, I changed my opinion about chemistry! Now I know the origin of many materials and I understand many technological processes",

"When I find chemistry course in our time-table I asked myself "Why should we study it?", but now I treat chemistry very seriously".

The answers to the second question were predictable (Fig.2). Most of the students noted that interesting themes for them were "Electrochemistry" (16 students) and "Chemistry of Metals" (12 students). The most boring and difficult theme was "Ionic equilibrium and hydrolysis" (6 students).

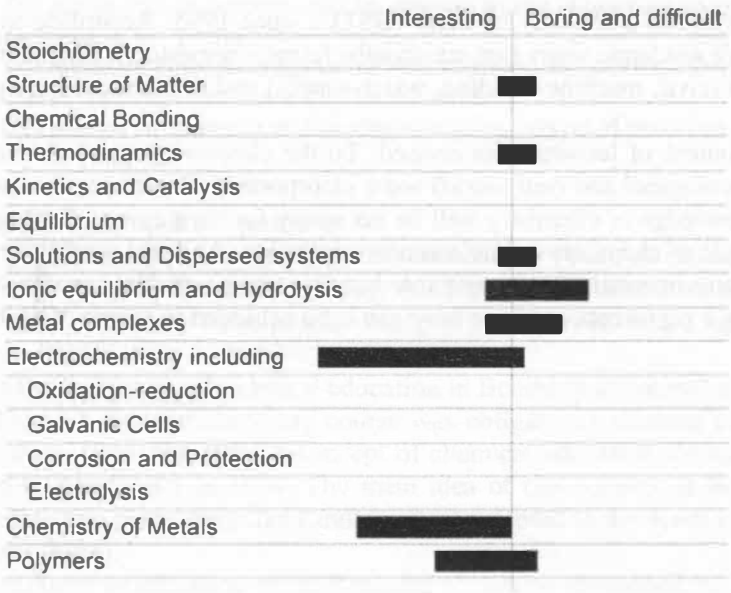

Figure 2. The students' "voting" for the themes of curriculum.

Most of the students didn't make any wishes to improve organization of chemistry course. To make chemistry more interesting 6 students proposed to include to lectures and labs more experiments and practical tasks, and one student propose an excursion to chemical plants.

Also our study involved an end-semester examination for the students. Examination consists of a fourteen test questions, two practical tasks and one theoretical question. The questions not only require the use of memorized algorithm, but some of them provide an application of knowledge to different practical situations. All of 101 students were allowed to take the examination and all students passed it at first attempt. The results of examination are represented in Table 1.

Table 1. The results of examination.

Mark*	10	9	8	7	6	5	4	3,2,1
Number of students	1	13	23	28	21	12	3	0

* – In Belarus 10 is the highest mark. Marks 3, 2 and 1 seem that examination is not passed.

It is evident that most of the students passed the examination successfully with high marks. Analysis of their examination answers show that less difficulties was on themes noted them in essays like interesting and important for their future activity.

Concluding remarks

The results of this study indicate that the quality of chemical education for would-be engineers can be improved by making chemistry more interesting and competitive. It can be achieved by:

- revising the content of lecture course by incorporating data shown the great role of chemistry not only in future professional activity of students, but also in sustainable development and every day life;
- revising the content of laboratory course by including practical engineering tasks.

This strategy produced increased participation by students of technical specialties in chemistry classes.

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