Curriculum Matters
Учебно съдържание, планове, програми и стандарти

TEACHING CHEMISTRY AT TECHNICAL UNIVERSITY

Lilyana Nacheva-Skopalik, Milena Koleva
Technical University of Gabrovo

Abstract. In the recent years, there have been several growing tendencies, which determine the increased necessity to educate adults. National Strategy for Continuing Professional Training has been developed. Priorities are given to further development of secondary and tertiary education with emphasis at quality of education and implementation of ICT. Tertiary education has its specific and important place in adult education and responsibility to provide high quality modern training conformed to the requirements of the labour market. Chemistry is one of the fundamental disciplines included in curricula for all students from the Faculty of Electrical Engineering and the Faculty of Mechanical Engineering at Technical University of Gabrovo. It is considered by students as an unintelligible and sophisticated science. Department of Chemistry faces some problems and challenges in order to compensate student's insufficient entry level of knowledge, to enhance students' motivation in learning chemistry and to make it an attractive discipline. As a part of activities for improving efficiency of chemistry training an enquiry among students is held in order to evaluate their opinion and satisfaction with a teaching course. The applyed approach gives qualitative and quantitative evaluation of the chosen quality criteria of the course. The results are used to make conclusions for improving the teaching course beginning with quality criteria with the biggest importance. It includes decision to develop and intoductory e-learning course to achieve required starting level of knowledge. The measures taken contribute to enhanced efficiency and incresed attractiveness of chemistry and enchanced students' motivation for learning chemistry.

Keywords: e-learning; decision making; evaluation of opinions; satisfaction measurement

Education – national priority for 2014 – 2020.

In the recent years, there have been several growing tendencies, which determine the increased necessity to educate adults such as growing number of school drop-outs, increased number of unemployed specialists holding a university degree, great number of specialists with a tertiary education degree taking a position requiring lower qualifications. National Strategy for Continuing Professional Training[1)] has been developed. Priorities

are given to activities for further development of secondary and tertiary education with emphasis at quality of education and implementation of ICT.[2,3)]

The educational conception "life-long learning" opens opportunities in front of the particular person to live a dynamic and reasonable life, to develop a personal, professional carrier and good perspectives.[4)] The dynamics of the modern economy requires constant increase of the qualification of the people, acquiring new knowledge and skills in order for them to become more adaptable to the needs of the labour market.

Developing of lifelong learning (LLL) is one of the priorities in Bulgarian education system, in compliance with the Bologna Process. Bulgarian Ministry of Education, Youth and Science has developed a National Strategy for LLL for the period 2008 – 2013.[5)] According to he the Lisbon strategy around 13% of all actively working adults (age group 25-64) are expected be involved in LLL activities. A survey conducted in 2005 by Eurostat among the labour force of EU countries shows that for Bulgaria this figure is 1,3%. It is obvious that there is a lot to do in order to make LLL common practice in Bulgaria. Persons from younger age segment, e.g (25-34) are considerably more active in formal and informal education or training. Priorities are given to activities determined by the above reasons. All these activities are a significant part of the process of development of secondary and tertiary education in the Republic of Bulgaria. The major trends are connected with: quality of education; equal access to education; vocational training; labour market; improving of teacher training; wider implementation of ICT in education.

Possible trends for further development of educational system include: (i) establishment of higher schools as potential lifelong learning centres; (ii) strong emphasis on the private sector in tertiary education; stimulation of partnership with business; (iii) enhanced practical orientation of training and learning at universities and colleges; (iv) provision of equal access to quality higher education.

Tertiary education has its specific and important place in adult education and the responsibility to provide high quality modern training conformed to the requirements of the labour market. Achieving this goal has never been an easy task and it is a particular challenge in the current dynamic and changeable world. Over the last a few years Bulgarian universities have been facing the ever increasing competition on behalf of foreign universities. Assistance of National Agency for Assessment and Accreditation in providing conditions for the real modernization and reforming of tertiary education institutions and its contribution in creating a solid public trust in higher education has been marginal. In the light of the above, the challenges confronting higher education generate additional gravity. Some of the specific cases to mention are[2)] (Koleva & Nacheva-Skopalik, 2012): (a) Frequent criticism on behalf of employers concerning the quality and adequacy of preparation of university graduates; (b) Shortage of financial

resources for the provision of modern educational process conducted by highly qualified academics; (c) Demographic crisis in the society, accompanied by diminishing the number of potential students amongst young people and increase in the number of the people in more advanced age who need to acquire new knowledge and skills; (d) Change in the profile of the students as more and more of them prefer learning combined with some form of work; (e) An alarming long standing tendency towards deterioration of literacy level; (f) University strategies for lifelong learning should be developed in accordance with three basic principles: - Flexibility at the entry and exit of educational institutions as well as during the very process of education (for example, accreditation of skills acquired at the work place); - Orientation of the process of learning toward labour market and student needs; - Building up networks and partnerships with other institutions of higher learning and most of all with businesses.

Technical subjects and engineering education have been neglected for the last years, however, currently an increasing need and importance of technical subjects for industrial development and knowledge based economy is observed.

Council of Ministers of Republic of Bulgaria declared science and education as a national priority for the period 2014-2020[3)]. A new operational program „Science and education for intelligent growth 2014-2020" has been launched, managed by the Bulgarian Ministry of Education, Youth and Science.[6)] The main strategic goal is achieving intelligent growth and development of knowledge-based society trough quality improvement of research and education. Five priority areas are specified which include research and technology development, education for real employment, mobility and entrepreneurship, and education, skills and life-long learning. Special attention is paid at: (A) Improving quality of higher education; (B) Increasing the number of university graduates for age group 30-34, achieving inclusion at 36% until 2020; (C) Providing conditions for development of life-long personal and professional knowledge and skills.

Universities have the difficult task to solve this problem and Technical University of Gabrovo is not an exception.

Teaching chemistry at technical universities

Chemistry is one of the fundamental disciplines included in curricula for all students from the Faculty of Electrical Engineering (FEE) and the Faculty of Mechanical Engineering (FME) at Technical University of Gabrovo.

Department of Chemistry faces some problems and challenges. Chemistry is considered by students as an unintelligible and sophisticated science. According to learners some of the most frequently faced difficulties in chemistry studies at school are connected with poorly presented content of course books, poor methods of teaching and assessment,

outdated, inadequate or unavailable laboratory equipment (Gendjova, 2014; Peteva et al., 2014). Most of the interviewed secondary school students share the opinion that chemistry is an unintelligible and sophisticated science (Bozova & Bozov, 2014). There is no particular interest in chemistry and that is a process which has been going on for years (Gendjova, 2014; Peteva et al., 2014, Thimmappa, 2014). The discipline remains underrated, the material taught is not oriented to practice which makes it not topical. Therefore way of teaching and its further practical applicability are of crucial importance (Thimmappa, 2014). Additionally, the student's knowledge in this discipline from the secondary school varies a lot[4)] (Koleva & Nacheva-Skopalik, 2012).

Therefore the department faces an urgent need to compensate student's insufficient entry level of knowledge, to improve quality and enhance efficiency of teaching chemistry to enhance students' motivation in learning chemistry and to make it an attractive discipline.

The Chemistry department is involved in different activities aimed at these crucial goals. Our investigation shows that in order to have a complex approach to solve the problems they have to be explored from different points of view. There is need to consider three main areas: (i) best practices; (ii) chemistry teachers' and experts' experience and to apply their joint efforts; (iii) students' opinion for chemistry training.

Some of the mentioned problems are not only local and national, but common for most EU countries. The work connected with the first two directions is part of an European project, funded in the framework of the Lifelong Learning Programme, Comenius sub programme. TU-Gabrovo is a partner in "Chemistry is All Around Network Project". The network involves 13 partners from 11 European countries among which universities, education and training organizations and one technical partner.[7)]

Analysis of various practical cases shows that promoting life-long learning strategies for scientific issues is much more difficult, if compared to other subject areas (e.g. humanities, economics and languages). Additionally, teachers, as key factors of the promotion of scientific awareness, have to face a major challenge coming from the fact that the speed of the development of scientific knowledge is continually increasing. Chemistry is recognised as one of the most difficult scientific subjects and therefore the "Chemistry is All Around Network project" aims at stimulating the interest of students towards the study of chemistry.

The general aim will be achieved through various specific objectives, which include: (i) Enhance the interest and stimulate the active learning process of students of all educational levels, by sharing the most effective ICT based practical experiences; (ii) Create a working European Network for the exchange and comparison of experiences and knowledge in order to promote chemistry training.

Project program aim at active involvement of chemistry scientific experts and teachers in a joint effort to share experience, firstly, about the national and international state of art regarding the main obstacles that affect the interest of students for chemistry and, secondly, about initiatives, methodological approaches, didactical solutions that demonstrated to be effective in answering to the identified barriers. The results obtained will contribute not only to presenting the actual state of the art but will suggest ideas for future perspectives of teaching chemistry. Expected effect is to specify more innovative, attractive and interactive approach in teaching chemistry and to suggest solutions for promoting the learning of chemistry by making it more attractive to students through the use of ICTs. The project stresses on the exploitation and valorisation of enquiry based teaching methods and solutions. Evaluation of the project by the teachers and adult users proves its necessity and importance as efficient and non traditional instrument to enhance the interest in learning chemistry to make chemistry closer to people and more attractive for students.

The activities mentioned so far cover two of the three specified directions of work. Teaching is two-way process, interaction between teachers and students. Therefore exploring students' opinion is necessary I order to complete the full picture of teaching and learning. Further more, our research proves that in order to achieve efficient optimal learning process we have to apply principles of feedback system where obligatory component is evaluation of the feedback from students (Nacheva-Skopalik, 2007).

Our experience in evaluation of students' opinion for chemistry course in presented in this paper.

Efficiency of a teaching course

Efficiency of education system depends on various factors, which can be defined in the following main groups: directly connected with the teaching process and courses, psychological influence on the students, organizational, administrative, and financial. Additionally, there are various national and regional differences, type of education, culture and traditions and other factors in the education systems. Therefore, the complexity of the problem requires research in order to achieve effective education.

Full examination of efficiency of education requires involvement of wide range of specialists, including specialist in the knowledge domain, pedagogies, psychologists, sociologists, financial and management experts, mathematicians, etc. This is a work load of a wide scale, subject to a big national or international project.

A starting point for enhancing efficiency of education is enhancing efficiency of the teaching course and learning process. This is one of the directions for research and practical implementation of Department of Chemistry at TU-Gabrovo. Some of the work done and the experience gained are presented in this paper.

Quality management system approaches in education

One of the criteria for the potential of a nation is the quality and capacity of people's knowledge. This criterion is particularly important at the current stage of the society development. Knowledge is considered to be not only social good; it became a specific product (service). That is why there is increased attention to evaluation of quality and efficiency of education and the contribution of university education to the economic growth and increasing competitiveness. Higher education has to meet the needs of the society. Therefore the educational service has to fill the requirements of the quality standards.

Education is a specific service; however the main principles for quality management can be applied to it. As mentioned above, education is seen as a service of great public importance; however it is also of a great importance to the student. Students are seen as main "customers" of the service "education". Therefore a teaching course has to fill students' requirements.

ISO 9000 series standards require continual improvement of quality management system and evaluation of customers' satisfaction with the product (service).[8)] Customers' satisfaction with quality a product (service) as well as evaluation of efficiency is a subjective perception, depending on various criteria. Thus, it is necessary to apply multiple criteria optimization approaches in order to evaluate the level of customer satisfaction (Nacheva-Skopalik, 2010).

Quality of a product (service) is a complex characteristic which is in practice a set of various characteristics. Each quality characteristic is characterized by quantitative and qualitative valuations. The qualitative valuation defines the level of importance of the quality characteristic. The quantitative valuation gives the level of customer satisfaction with this quality characteristic. The combination of these two valuations gives a complex evaluation of the customer's satisfaction with the chosen quality characteristic (Nacheva-Skopalik, 2007; 2010). The developed approach for satisfaction measurement applies the method for calculating weighting coefficients to define the importance of the characteristics (qualitative valuation) (Stoyanov, 1993). The approach is reliable because the weighting coefficients are calculated only if there is concordance in the customers' opinion with defined probability.

The importance of the quality characteristics is significant at both stages: development of the product (service) and improving their quality[8)] (Nacheva-Skopalik, 2010). Four areas in the space of the weighting coefficients and the level of satisfaction are defined: area of high satisfaction and high importance; area of low satisfaction and low importance; area of low satisfaction and high importance; area of high satisfaction and low importance (Fig.1). The accepted limits of these areas can vary and are subject to define for the different practical cases. It is crucial to have high level of satisfaction for

the most important characteristics. The decision maker makes conclusions how and which characteristic to change in order to improve quality, depending on a particular final aim. It is logical always to start with characteristics with higher importance.

Evaluation of student's satisfaction with a teaching course in chemistry

The Department of Chemistry at Technical University of Gabrovo is actively working for improving quality of the teaching course in chemistry, increasing attractiveness of chemistry and students' motivation for learning chemistry. A lot of work has been done to develop teaching materials using modern information technologies, including attractive presentations, multimedia and animation; however, there is still field for more improvements (Nacheva-Skopalik, L. & Koleva M., 2012).

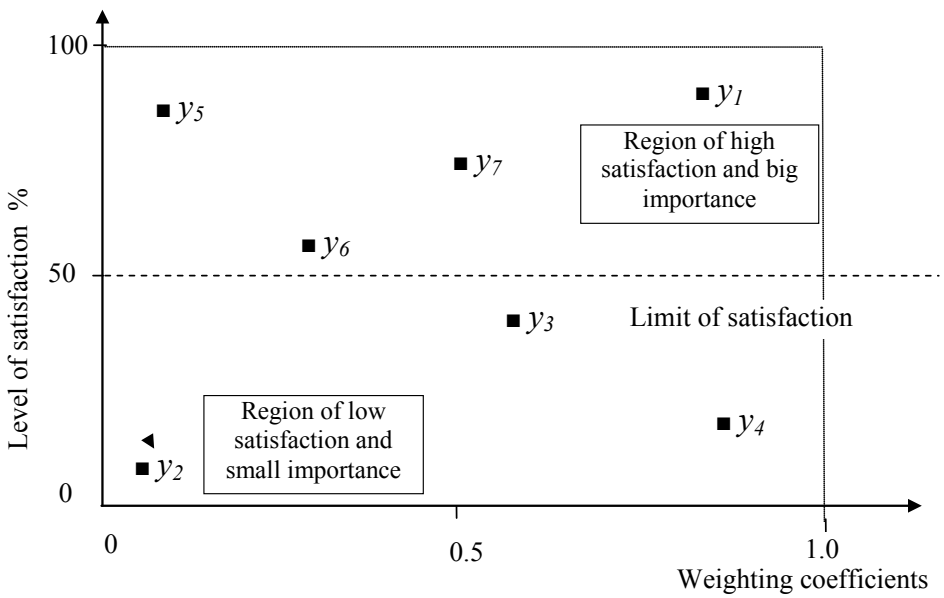

Figure 1. Level of satisfaction with quality characteristics

An enquiry among students aims at exploring students' opinion for the importance of the quality characteristics of the study course in order to direct the efforts for improvements to the most important ones. The enquiry gives also information for the level of students' satisfaction with the current course.

After discussions and consultancy with university academics 9 quality criteria for examination were defined and included in the enquiry card (Table 1.).

Table 1. Enquiry for a teaching course in chemistry - quality criteria

Quality criteria for a teaching course in chemistry		**RRank**	**Level of satisfaction**
Y1	Quality of the lectures – use of comprehensible and attractive approaches for presenting teaching material		
Y2	Small groups for the practical sessions		
Y3	Quality of the practical sessions - use of comprehensible and attractive approaches for presenting teaching material		
Y4	Available learning recourses		
Y5	Topical and practically directed teaching material		
Y6	Self-study (literature, consultations, internet access)		
Y7	Conditions for the learning process (laboratories equipment)		
Y8	Number of the students for lectures		
Y9	Objective and precise assessment		
Y10	Other (please, specify)		

The students are asked to give their opinion using a number between 0 and 10 in a column "Level of satisfaction with the characteristic (0-10). This number shows the level of their satisfaction with each quality characteristic. The number 0 means full lack of satisfaction, number 10 means full satisfaction. The students are asked to give their opinion by grading (arranging) the quality characteristics by their importance. They have to put ranks (priorities) in the column "Rank" to all given characteristics in the table using numbers. The highest rank (priority) is 1. The lowest rank (priority) is 10. In their opinion, they can put in the table equal ranks for some of the characteristics.

The target group is 1-st year students at FEE. An anonymous enquiry was made during the last week of the summer semester of 2011/2012 academic year, after having some tests during the semester. Enquiry results re presented in Table 2 and Fig.1.

Table 2. Enquiry results

Quality criteria		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	total
FME 2011	weight coeff.	0,185	0,119	0,206	0,147	0,103	0,062	0,079	0,008	0,091	
	rank	2	4	1	3	5	8	7	9	6	
	satisfaction	78,6%	67,1%	71,4%	70,0%	67,1%	61,4%	67,1%	58,6%	71,4%	70,5%
FEE 2011	weight coeff.	0,146	0,128	0,145	0,092	0,095	0,080	0,124	0,070	0,120	
	rank	1	3	2	7	6	8	4	9	5	
	satisfaction	73,8%	71,5%	69,2%	64,8%	61,7%	63,5%	61,7%	45,0%	67,3%	65,7%
FEE 2012	weight coeff.	0,147	0,129	0,120	0,118	0,113	0,083	0,109	0,084	0,097	
	rank	1	2	3	4	5	9	6	8	7	
	satisfaction	69,4%	77,6%	74,4%	69,2%	70,2%	67,8%	72,2%	68,8%	71,8%	71,3%

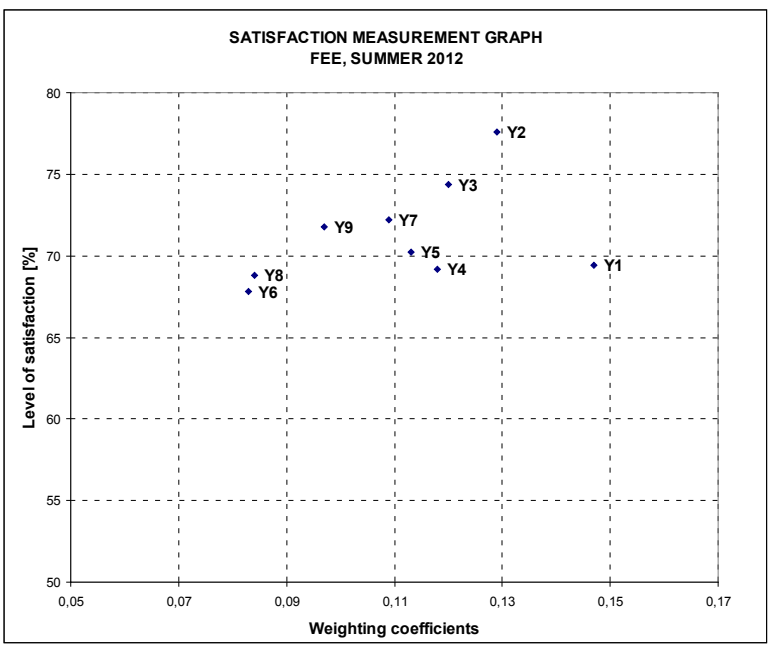

Figure 2. Satisfaction measurement graph

The first four ranked characteristics are: quality of the lectures – use of comprehensible and attractive approaches for presenting teaching material (Y1), small groups for the practical sessions (Y2), quality of the practical sessions - use of comprehensible and attractive approaches for presenting teaching material (Y3), available learning recourses

(Y4). All of them are with satisfaction level above 60% which is rewarding result for the efforts made to improve the course. However, there is still need to improve Y1 and Y4, which are important and currently with relatively low satisfaction level among the other characteristics.

Looking at the results form the previous investigation it is seen that the first 4 characteristics can be defined as most important.

Measures taken for improving quality and efficiency of chemistry course

The results are used to make conclusions for improving the teaching course beginning with quality criteria with the biggest importance. After discussing the enquiry results and sharing the personal experience of chemistry module lecturers the team came to the decision to develop an introductory interactive e-learning course in chemistry. Such a course will compensate the lack of entry knowledge level of the students and will provide background to achieve the learning outcomes of the university course in chemistry. Using the power of the modern multimedia approaches the course aim is to improve quality and enhancing efficiency of teaching chemistry, to make the subject attractive to students, to motivate and stimulate their learning.

Conclusion

Education is a national priority for Bulgarian policy for the period 2014-20. An emphasis is given to further development of higher education, including extended options for life-long learning and wider introducing of ICT. Improving quality and enhancing efficiency of teaching chemistry is an integral part of the common efforts for improving quality of university education. Department of Chemistry works in various directions to achieve this goal. Evaluation of students' opinion and their satisfaction with chemistry course contributes to making relevant decisions in this direction.

NOTES

1. National strategy for continuing vocational training 2005 – 2010, Ministry of education, youth and science.
2. Eurybase - Bulgaria, The Information Database on Education Systems in Europe - 2005/06.
3. http://www.mon.bg/?go=news&p=detail&newsId=31
4. The educational conception for „Life Long Learning" in Bulgaria, BG-National Report, N° 167126-LLP-1-2009-1-IT-KA1-KA1ECETB.
5. National strategy for lifelong learning (LLL) for the period 2008 – 2013, Ministry of education, youth and science.

6. http://www.minedu.government.bg/news-home/2013/13-01-10_OP-nauka.html
7. http://chemistrynetwork.pixel-online.org/info/index.php
8. http://www.mon.bg/?go=news&p=detail&newsId=31

REFERENCES

Bozova, M. & Bozov, P. (2014). How to motivate pupils of 7th grade to learn, *Chemistry, 23,* 18-27 [in Bulgarian].

Gendjova, A. (2014) Some strategies for motivation students to learn chemistry, *Chemistry, 23,* 53-73 [in Bulgarian].

Koleva, M. & Nacheva-Skopalik L. (2012). Making chemistry an attractive subject for lifelong learning: interactive approach in presenting educational content (pp. 29-34). *The "New perspective in science education"*. 8 - 9 March, Florence, Italy.

Nacheva-Skopalik, L. (2007). *An examination of an intelligent cybernetic learning model for formative assessment and diagnostics in open and distance learning*: *PhD thesis*. Middlesbrough: Teesside University.

Nacheva-Skopalik, L. (2010). Satisfaction measurement in education (pp. 436-466). In: Lazarinis, F., Green, S. & Pearson, E. (Eds). *Handbook of Research on E-Learning Standards and Interoperability: Frameworks and Issues*. New York: IGI Global.

Peteva, Z., Makedonski, D. & Stancheva, M. (2014). Incresing student's interest in chemnistry with context-based approaches for control and assessment in English language program at Medical University in Varna, *Chemistry, 23,* 73-88.

Stoyanov, S. (1993). *Optimization of technological processes*. Sofia: Tehnika [in Bulgarian].

Thimmappa, B.H.S. (2013). Perspectives on technology enhanced learning and teaching for an exciting learning experience, *Chemistry, 22,* 30-52.

✉ **Dr. Lilyana Nacheva-Skopalik**
Department of Applied Informatics
Technical University of Gabrovo
4, H. Dimitar Str.
Gabrovo, Bulgaria
E-mail: liliskopalik@mail.bg

✉ **Dr. Milena Koleva**
Department of Physics, Chemistry and Ecology
Technical University of Gabrovo
4, H. Dimitar Str.
Gabrovo, Bulgaria
E-mail: kolevamilena@hotmail.com