

## Sustainable Development of Chemistry E-learning

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### Abstract

One of the considerable disadvantages of Bulgarian educational system in the area of higher education is that it does not offer enough lifelong learning opportunities. In reply to the increasing need for more effective learning forms the Technical University of Gabrovo has developed sets of interactive learning materials designed for students following different bachelor and master degree courses. They have been elaborated within the project BG051PO001-4.3.04 funded by the European Social Fund. Some of the sets are based on the learning content of the general subjects in secondary school such as Mathematics, Physics, Chemistry. They are intended for the so called "compensation learning" whose aim is to eliminate the learning differences in the different types of secondary schools and to build the required volume of knowledge providing an equal entry level of knowledge to the first-year university students so that they can better cope with their academic studies. The present paper considers the development methodology and the results from experimental testing of the interactive learning course for "compensation e-learning" in Chemistry – a subject included in the curricula of all bachelor engineering degree courses offered at the University. Survey was carried out among the students attended the testing in order to study their opinion about the applied reaching approach. The results show that they highly appreciate such a learning course because of the opportunity for not limited in time and place autonomous self-study (something which extremely relieves part-time students), the learning content presented in easy to understand way, and its effectiveness in compensation of missing knowledge from secondary school. The last one, in turn, eases their academic studies.

### 1 European and National aspects of e-Learning

Contemporary information society is characterized by unprecedented dynamic development of information and communication technologies (ICT) and their active use in all economic and social activities. This defines a new social structure, organization and social relations which are based on the global access and use of information and communication networks and services. The use of ICT is a European priority, supported by the Digital agenda initiative [1]. Over the last years, ICT are actively applied in the field of education, whereas one of the most promising forms of application is e-learning. E-learning is a European priority for the "Europe 2020" strategy, which aims to deliver an intelligent sustainable growth through more effective tools in education, research and innovation. One of its five ambitious objectives is related to education, whereas the stress is exactly on the use of digital technologies at all levels of education, for improving the quality of training and the attractiveness of Europe's universities [2-5]. International organizations such as European Distance and E-learning Network (EDEN) and the European Foundation for Quality in E-learning also hold active activity on development and deployment of e-learning.

As an EU member, Bulgaria adopts the general objectives of Europe 2020 and adapts them through the National Programme for the Development of Bulgaria 2020, in which science and education were identified as a priority [6]. One of the main tasks of the Operational Programme "Science and education for intelligent growth 2014-2020" is to improve the quality of university education and its technological development by introducing information and communication technologies. Its implementation is financially backed by the Operational Programme "Human Resources Development" and the European Social Fund through grant priority to a number of schemes for the development and modernization of education, in particular - university education, such as: "Development of electronic distance learning in university education", "Updating the curriculum in university education in accordance with the requirements of the labour market", "Improvement of management in higher education", "System for training and career development of teachers in higher education", "Support for the development of PhD students, postdoctoral scholars and young scientists". The document "Europe 2020: National Reform Programme" underlines the need for Bulgaria to compensate for the lagging behind the other EU member states by reforming the system of university education, including the promotion of flexible forms of modern training [5, 7-9].

Sustainable development of e-learning is set as a priority of the Technical University - Gabrovo for the period 2012 - 2015 as part of the activities of its establishment as a competitive university offering advanced training with guaranteed quality in compliance with the dynamic changes in the labour market. A centre for distance and e-learning at the university deals with the organization, operation and development of forms of electronic and distance learning [10]. Activities within the project BG051PO001-4.3.04-0051-C0001-D01-396 "Development and implementation of virtual technologies for sustainable development of distance learning in the Technical University of Gabrovo" over the last two years contributed to the development and successful implementation of the forms of e-learning in the university [11]. The project is aimed at introducing modern virtual technologies in training, thus expanding the scope of offered educational services and access to new groups of students to meet business needs of highly qualified personnel.

## **2 Chemistry learning: from secondary school to the university**

As a part of the fundamental education Chemistry learning in Bulgarian starts in the primary school and continues in the secondary for a period of 2 - 3 years depending on the school profile. The process finishes in the university degree where (with the exception of the specialized universities) the subject is taught/studied for one semester only. As it is the final stage of the science education, the success of the academic course depends strongly on the quality of the fundamental knowledge and key competences developed during the school education.

Negative tendency of Bulgarian school education nowadays is the lack of interest among young people in scientific issues. Among them Chemistry is recognised as one of the most problematic and difficult subjects. A survey performed under Chemistry is all around Network European Project among school chemistry teachers and students shows similar opinion concerning difficulties in acquisition Chemistry learning material:

- Academic style of course book content which is difficult to understand for students - course and reference books in Chemistry are theorized which demotivates the students;
- Material taught is not oriented to practice;
- Not enough training courses for teachers related to the interactive methods of teaching chemistry;
- Lack of synchrony between the specialists in information technologies who could work out interactive education and demonstration materials for visualization of difficult for demonstration "alive" of chemical processes and the teachers in chemistry who could present the corresponding tasks and education contents with the aid of these materials;
- The number of Chemistry classes is insufficient at school and, as the usual practice is, there is no time for lab exercises;
- Depreciated material base and insufficient modern equipment – one of the most serious problems related with the study of Chemistry.

As a result most of students perceive Chemistry as complicated and incomprehensible subject, filled with formulae, mathematic expressions and long inapprehensible terms. They are poorly motivated for learning Chemistry [12, 13]. This result affects very negatively the quality of the learning process and its results in university education in chemistry.

One of the tools to overcome the negative trends in both school and university education in natural sciences, including chemistry, is the use of modern educational approaches and information technology for presentation in an easily comprehensible manner the difficult to absorb material through the use of video lessons, animations, interactive and other materials that enhance the interest of students and motivate them to study chemistry.

## **3 Compensation e- Learning in Chemistry**

### **3.1. Methodology**

In order to improve efficiency in the use of knowledge from the academic course in chemistry and especially to facilitate students in their preparations for the discipline, a set of interactive teaching materials on chemistry intended for the so called "compensation learning" was developed. It aims to eliminate the learning differences in the different types of secondary schools and to build the required volume of knowledge providing an equal entry level of knowledge to the first-year university students so that they can better cope with their academic studies. The development methodology is based on the analysis of the findings of the survey carried out among the students following the above mentioned degree courses, and related to the quality of the Chemistry training provided at the

University [14]. The learning materials are developed on the basis of the Moodle platform, which is one of the most widely used worldwide for academic purposes, within the project BG051PO001-4.3.04 funded by the European Social Fund.

The theoretical learning content is divided into 6 modules, each of which covers a few topics. Each topic consists of one or more short presentations that are easy to understand, illustrations, links to web sites and other interactive tools – actually they all help to present the main issues of the learning content of the Chemistry subject taught at secondary school (Fig.1). A database is developed for each topic, where the students can find relevant web sites, literature resources, video materials, etc. so as to expand their knowledge in the respective area.

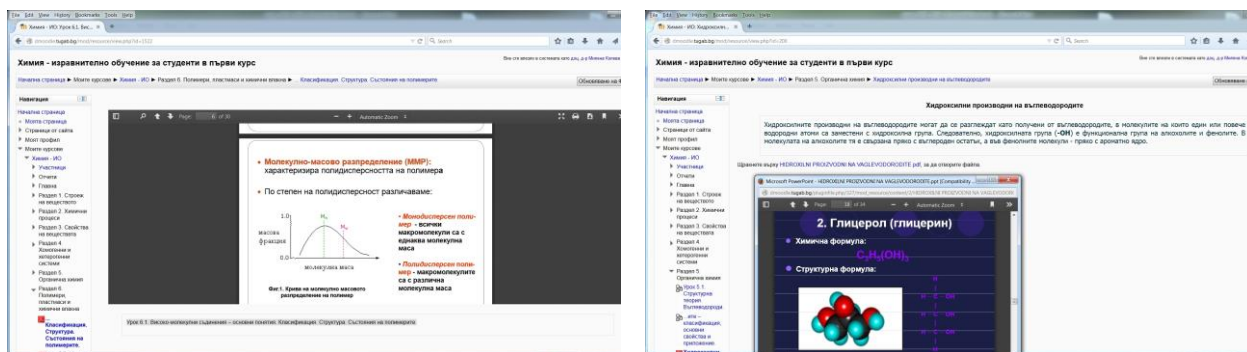


Fig.1. Compensation e- Learning in Chemistry - presentation of theoretical content

A separate module with tests is elaborated for each topic. The tests have three levels of difficulty - the second- and third-level tests are intended for carrying out assessment by the teachers - they are mandatory. The test results could be statistically processed in order to monitor the quality of the educational process (Fig.2).

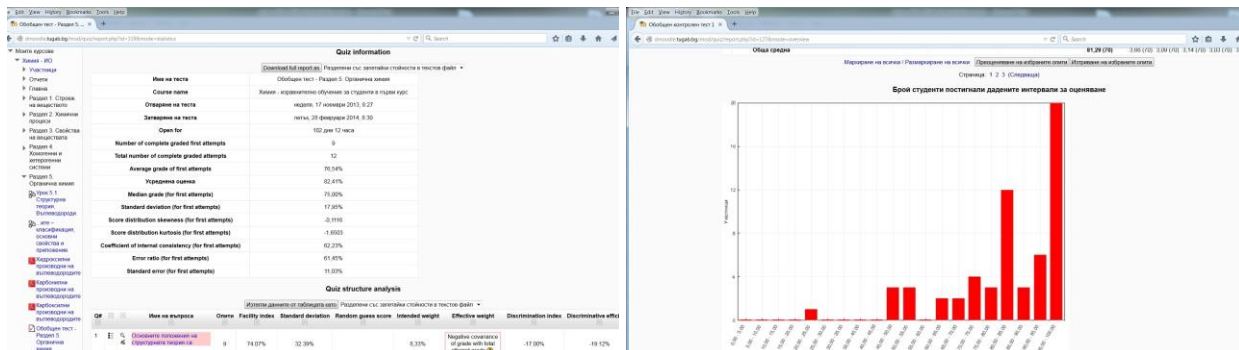


Fig.2. Compensation e- Learning in Chemistry – tests results statistical information

The overall scheme of the course is built on the principle of gradual upgrading of knowledge, increasing the degree of difficulty and expanding the scope of information.

The first module "Structure of Matter" recalls construction, aggregate, phase and physical states of matter. It also examines the chemical elements, the periodic law and the principles of construction of the periodic table, chemical symbols and formulas, and how to use them for expression of chemical interactions. It also considers the types of chemical bonds.

The second module is dedicated to chemical processes and conditions for their conduct - speed and thermal effects of chemical reactions, chemical equilibrium. Particular attention is paid to the redox processes and their application.

The module "Properties of substances" gives a general characteristic of the chemical elements and the main groups of compounds - oxides, hydroxides, acids, salts. Since a number of disciplines in the specialized academic training in engineering disciplines are associated with processing and application of metals and metal alloys, the module targets information on the structure, physical and chemical properties of metals and methods for their preparation.

A separate module is dedicated to the dispersion - homogeneous and heterogeneous - and especially to true solutions. The mechanism and characteristics of processes such as electrolytic dissociation, neutralization and hydrolysis are considered. The term "pH" is introduced.

The module "Organic Chemistry" recalls the essentials of school course in Organic Chemistry: basic principles of structural theory; hydrocarbons; classification, basic properties and use of derivatives of hydrocarbons - hydroxyl, carbonyl and carboxyl.

The last, sixth module is specialized and the information it contains is of a higher degree of difficulty. Its aim is to form knowledge of high molecular compounds (basic concepts, classification, structure, phase and physical states), their characteristics and properties, methods of preparation and application. Thematic topic is closely related to plastics and textile fibres and the choice is determined by the fact that the academic training of engineering majors covers disciplines such as electro material science, textile material science, equipment and technologies for waste processing, recycling materials that require knowledge in the field of polymers.

### 3.2 Experimental testing – results and discussion

Interactive e-learning materials were experimentally applied to countervailing training in chemistry of the new students in Computer Systems and Technologies (CST) and mobile and satellite communications in the Department of Electrical and Electronic Engineering in the academic year 2013/2014. The "Chemistry" course for both specialties is part of the basic training and is taught only in the first semester, along with subjects such as Mathematics, Physics, Informatics, which create the basis for further specialized training of students. In this respect, the knowledge accumulated in the secondary school, in quantitative and qualitative aspect are essential for the absorption of the academic material. The main source of students in both engineering majors are vocational secondary schools in the country, specialized mainly in the field of electrical engineering and electronics, computer technologies and communications, who studied Chemistry for 2-3 years having extremely insufficient classes. A small part of the students come from secondary schools where discipline is studied for 4-5 years. These features of school education in Bulgaria and the difference in duration, number of hours and the quality of education in chemistry, give grounds for the different level of students' basic knowledge - in most cases minimal or completely missing - and are a prerequisite for low quality of university education.

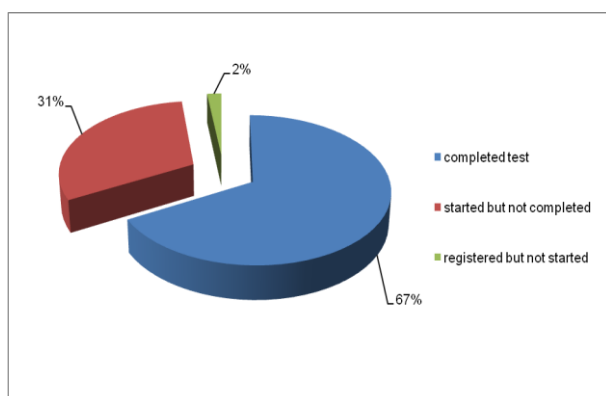


Fig.3. Distribution of participants attended the experimental testing

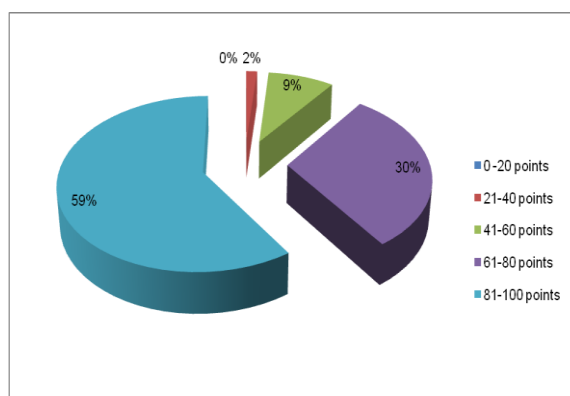


Fig.4. Distribution of results obtained by completing of general control test

The training was conducted in the first two weeks of the semester, before the beginning of the main academic course and due to its experimental nature, it was not obligatory. Working with educational materials was independent, but with assistance of the teachers.

103 students registered for participation, whereas the majority of them – 101 students – reached the third level tests which summarize the material from all modules. Over 65% of these students have solved successfully the summary control test (Fig.3). Another 30% have started, but because of difficulties have not completed it. A minimal number of students have registered in the system, but have not solved the test.

The final results of experimental learning with interactive materials are more than satisfactory. About 90% of students have achieved over 60 points in solving test of 100 possible, and nearly 60% of them

have achieved scores in the range 81-100 (Fig. 4). About 10% of students have not solved the test successfully.

In order to establish the role of countervailing training and developed interactive materials for learning academic course in Chemistry and increase the success rate of students in the current academic year 2014-2015, an experimental study is conducted, which includes students from the same majors, regular and part-time forms of training. Analysis of results and of survey on students' opinion will be used to optimize the content of the course, the presentations of the material for self-study, self-assessment and evaluation of knowledge.

#### 4 Conclusions

The result at the end of the experimental testing survey among students who participated in the countervailing training with developed interactive materials within the project on e-learning and the opportunities it offers, is indicative of the desire and motivation to participate in such an innovative form of training - 95 % of respondents welcome and approve e-learning due to the possibility of using attractive methods of presentation of the material and, especially, for independent work regardless of time and place. Over 80% are convinced of the need to use methods and tools for e-learning related to access to Internet and web-based learning materials in university training. The majority of students consider it acceptable that results from e-learning are used in course work assessment during training at university. All these results make reasonable the implementation of e-learning as innovative approach in basic academic courses in Chemistry or Chemistry related subjects for bachelor and master degree of education.

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