

Making Electronic Tests for Assessment and Self-assessment of Students in Chemistry and Environmental Protection on Moodle as a Part of a Quality Management System

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ABSTRACT

The article reviews the making of electronic tests for Assessment and Self-assessment of Students in Chemistry and Environmental Protection in Moodle, as a part of a quality management process. In this article Moodle's (www.informacia.org) e-tests programming methods and the Chemistry Question bank are shown. The present research reviews the influence that the e-tests have on students' learning motivation. The students demonstrated lack of experience in taking e-tests, due to the absence of good practices in using e-tests in Chemistry and Environmental Protection in the public and municipal schools, regardless the fact that Moodle has become very popular from 2007 onwards. The e-tests are estimated by the students as the most user-friendly docimological method.

***Keywords:** e-tests, electronic learning, Moodle, Chemistry and Environmental protection, electronic assessment, electronic self-assessment.*

INTRODUCTION

The new Bulgarian Law on Pre-School and School Education introduced some new and indispensable elements in the education like the Quality Management System (QMS) (ISO 9001), together with the world educational principle for development of digital skills and e-education. In addition, the education is seen as a universal service and all the qualitative and quantitative methods and phenomena existing in the industry can find their analogue in the educational system and

teaching technology [1 - 2]. The concept of Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP 17025) and Standard Operating Procedures (SOP) are transformed in good teaching practice and Learning Operating Procedures as a part of QMS 9001. The certified quality in the education system implies better training services. Furthermore, the quality certificates require a new type of training and learning methods, more friendly and useful for the contemporary students. All of that brings out the importance and efficiency of the e-learning and the e-education as

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teaching method. Moreover, the new technologies create new interactive educational methods [3 - 4]. The digital skills, developed since school-age, are the key for successful professional achievements after the secondary school [5]. By the moment there is no uniform vision, nor a program for an e-education in the secondary school in Chemistry in Bulgaria, because the nomenclature of subjects is really wide and there are different specific requirements for the various units [6]. Therefore, the papers regarding the matter review only a specific course of study, which is part of the program for the specific profession and job [7]. Unfortunately, the e-learning, the e-assessment and e-self-assessment are not fully implemented in the educational course of the secondary school as yet. A very small number of new e-tests were made in few secondary schools in Bulgaria, regardless the high educational potential of the assessment and self-assessment through e-tests.

Furthermore, the enormous application of the Chemical science and technology in everyday's life and practice [8] is indisputable. For this reason the aim of the present study is to develop Chemistry and Environmental Protection (CEP) e-tests for electronic assessment and self-assessment, as an element of Quality Management Systems and as an endorsement of the development of digital competences.

One of the most frequently used educational applications in the e-learning courses is the Moodle one. Moodle is an e-learning management system, which appeared for the first time in 1999, it was further developed in 2001 and has won several e-Learning Guild awards in 2007. Nowadays Moodle functions not only as a web site, but also as mobile application – the Moodle Mobile app.

In order to meet the requirements of the modern education and of the QMS, within the present study were established the following goals:

Vetting (analysis) of the methods and of the possibilities to develop Chemistry and Environmental Protection e-tests through Moodle's platform (www.informacia.org)

Create a Chemistry and Environmental Protection question bank for the e-tests in Moodle (www.informacia.org).

Verify the e-tests and their assessment provided the methods from point 1.

The scope of this study is the subject-oriented and dynamic potential of the educational platform of Moodle, with a view to enhance the objective assessment and self-assessment of the knowledge of Chemistry and Environmental Protection of the students from the Educational center "Elina" and to improve their capacity to work with Science application software and in particular, with a Chemistry application software.

EXPERIMENTAL

Target group

A group of 30 students from the upper secondary school was assessed and self-assessed: students from 11th and 12th grade, 17-19 year-olds, from higher schools.

Set-up of e-tests

The CEP e-tests include the following units: **Thermochemistry, Kinetics, Catalysis, Chemical balance, Electrolytic dissociation theory, Electrolytes, Ion exchange and Hydrolysis processes and Redox processes**. The content of the e-tests corresponds to the Educational standards of the State and to the secondary school syllabus, in the general and vocational CPE classes, established under the provisions of a Ministerial Decree of the Ministry for Education and Science.

The tests have two types of questions - open and closed. The closed ones are **Multiple Choice questions (MCQ), Matching, Numerical, Select missing words, True/False**. The MCQ are with one or multiple answers.

The open questions ask the respondent to write chemical equations; to establish the links and the correlations between different substances and between the chemical phenomena and pathways; to write essay on chemical problem; to think about the solution of a specific problem etc. This type of

questions requires: to fill in the blank spaces in a text; to complete a text; to indicate the relationship between the formulas of the substances and their names, as per the nomenclature of IUPAC, and also their trivial names; stoichiometric problems solving; to order substances, paths, phenomena, thermodynamic parameters in ascending or descending order, depending on their properties; problem solving of type “transition” - express the processes with chemical equations, expose the possible chemical reactions with chemical equations; assemble chemical equipment for a laboratory environment; analytical problems - to prove and establish unknown substances through the usage of indicator or through appropriate quality reactions (quality analysis); establish the correlation between the substances and their application in the practice. The open questions are created in Moodle as **Calculated, Calculated multi-choice, Calculated simple, Drag and drop into text, Drag and drop markers, Drag and drop onto image, Embedded answers (Cloze), Essay, Multiple choice, Random short-answer matching, Short answer. Maximum input box size** is allowed in these types of questions.

In order to give more freedom of choice to the users and considering Moodle's capacities, the e-test solving does not have set specific date and time. Students have at their disposal the maximum possible time to study the units and to choose at their own discretion a convenient time to take the e-tests: the day (working, non-working day, an attendance or non-attendance day) and the hour (24 hours a day). The only limitation is that the tests are available to be taken for the period of three months, which starts from the date of the last lesson on the relevant subject. Unfortunately the test cannot be taken after that period of time in Moodle. That is why the sections **“Open and Close the quiz”** were disabled and the E-tests, which have been submitted after this period of time were not taken into account.

The role of the assessment and self-assess-

ment, ergo the test, is to evaluate the skills and the competences in CEP of the students and to obtain the closest possible simulation of a real environment for chemical problem solving. In addition, the test evaluates also students' ability to demonstrate their knowledge according to the principle **“in the right place at the right time”**, therefore the test aims also to stimulate the thought process in the shortest possible time. This way new skills, which require problem solution in the shortest possible timeframes, within the so-called **„deadline“**, are learned. The ability to work with deadlines is crucial for the developing of professional competencies, which are created from adolescence onwards [9]. By setting limited time to answer the e-tests - the possibility for the students to copy from each other, to look for an information or to „copy - paste“ information from books, from notes or from the internet, usually from Google, is significantly decreased. For this reason, the e-tests in Moodle are available to be taken within a specific **time limit**, i.e. the period of time in which the tests shall be completed is not included but is precluded in the time. Students' psychological and age specifics were considered when setting the **time limit**, in accordance with the well-known didactical principle “teachers take the test three times faster than students” [8]. This is the reason why for each one of the tests a different **“timeframe to answer” (time answering)** was set – it was set depending on the number of questions and depending on the time in which the teacher - examiner takes the same test put in the same conditions. In order to give more freedom to the students, there are no **time limits** for the solution of every question.

The maximum number of points for a single problem and the number of points for a correct answer are set ever since the tests creation. The points are distributed between the different questions, depending on their complexity and depending on the skills and competences, which are going to be evaluated and self-assessed. For

the check of the e-tests, during the programming of the questions, in Moodle were imported: the correct answer (**Answer - Grade**), an explanation of the questions and of the test (**Feedback – Specific and General**) and the value expressed as a percentage (**Grade**) for correct answer.

The test starts upon being opened. Regardless the number of solved or unsolved problems, the system starts automatically counting the set time and once the time is up, the test automatically stops (it is closed).

The questions and the respective answers are displayed in a **shuffle order** (enabled option on Moodle) for the different students, in order to avoid the attempts for copying, prompting and interaction between the students, for notes and checks in the Internet.

For this reason during the test the **Review option** for the below features is disabled:

The correct and the incorrect answer - **Whether correct**

The number of points when is marked the correct/incorrect answer - **Marks**

Specific feedback

General feedback

Right answer

Feedback for incorrect answer (**Overall feedback**)

The mentioned options can be enabled: **Immediately after the test; Later, while the quiz is still open; Once the quiz is closed.**

During the test students' is given the possibility to mark the questions (**flag this question**) on which they need some clarifications.

ASSESSMENT AND SELF-ASSESSMENT

The points system, whose maximum number of question points for a correct answer was set during the making of the e-tests is used for the assessment. The marks are distributed between the questions, depending on their difficulty and depending on the skills and competences that are being evaluated. The score for the different skills and competencies that are going to be assessed and the total test score from the test are a whole

number and are displayed as a six-point scale, „in words and in numbers“.

In order to avoid being restrictive, it was not used a penalty point (demerit point) system when preparing the e-tests in Chemistry and Environmental protection. There's no deduction of points when is given an incorrect answer.

Students can self-assess themselves after the assessment made by the teacher and in this case the self-assessment criteria and system are based entirely on student's personal opinion. The self-assessment can be made either for a single evaluated competence or for the entire test.

An assessment and self-assessment tables with the different skills and competences and the whole test are displayed after teacher's evaluation (Fig. 1). In this table students can write their self-assessment score. This way the students can note the differences between teachers' criteria used as an evaluation system and their own self-assessment system.

CHECKING OF THE E-TEST

The check and the summary of the questions can be made **automatically** or **manually**.

The automatic check and the summary are made through **Moodle's system**. When the correct answer is marked, the system displays the message "**Your answer is correct**".

Once the test is submitted, the system automatically displays the following data:

The questions from the test – **The attempt**

The correct and the incorrect answer to the questions which have been automatically checked - **Whether correct; Right answer**

An explanation why the answer is correct (a **Specific and General feedback**),

The obtained score (**Mark**) from the maximum amount of points for the specific question.

The **manual** check and the point evaluation are carried out by the teacher, through **Moodle's** platform, by writing the relevant explanations in the designated spaces (**Comment and Override mark**).

No	Assessment and self-assessment skills and competences		Assessment	Self-assessment
1	Conceptual apparatus and theoretical knowledge in Chemistry	Theory, grammar skills	Teacher	Student
2	Laboratory work, work with chemicals and instruments	Laboratory skills	Teacher	Student
3	Chemical utterance and culture, presentation skills on a chemical thesis	Writing skills	Teacher	Student
4	Application of knowledge in life and practice	Practical skills	Teacher	Student
5	Logical relations between chemicals and their properties and processes	Critical and logical thinking skills	Teacher	Student
6	Working with chemical literature, understanding and interpreting a chemical text	Reading skills	Teacher	Student
	Total		% correct answers	Self-assessment for whole test
	Average general score		Average(1:6)	Average(1:6)

Fig. 1. Assessment and self-assessment table.

The calculation of the score for the different assessment skills and competences and the whole test are automatically done by Moodle, once the total (**automatic and manual**) check of the test is being completed. The scores for the different skills and competences and the total score from the e-tests are shown in an assessment table and are displayed as a six-point scale „in words and in numbers“, along with the percentage of correct answers.

After the check and the evaluation of the closed questions, students are given the possibility to see the correct and the incorrect answers, the number of points given for each question and to read the summary provided by the teacher for every single question in the section **Comment**, under the form of **Specific** or **Common note**. The review of the checked and scored tests does not have any time limits.

RESULTS AND DISCUSSION

77 % from the students had difficulties in taking of the first electronic test – Thermochemistry (Fig. 2). They took the opportunity given by Moodle to provide a feedback to the teacher (**messages**) about the problems they had during the e-test. The difficulties that the students experienced are shown in Fig. 3.

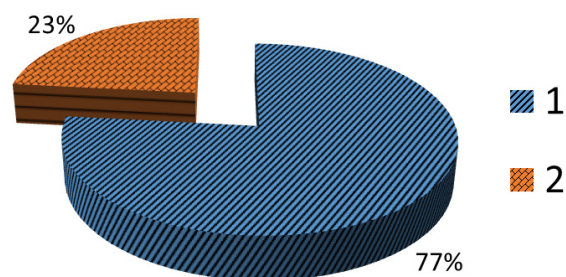


Fig. 2. Percentage of students that: 1- had difficulties during the first electronic test; 2 - did not have difficulties.

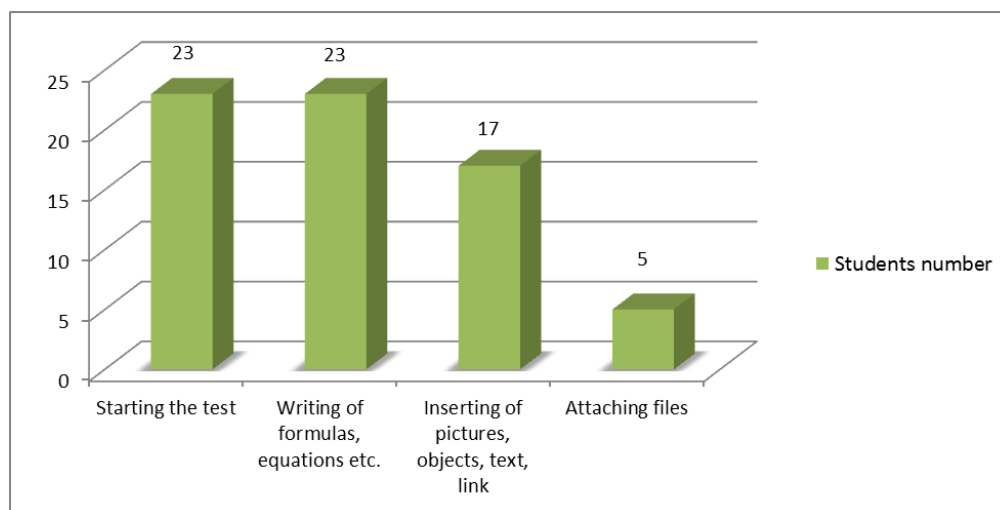


Fig. 3. Frequent difficulties during the e-test.

23 in 30 students experienced difficulties at the beginning of the test, since the Internet browser failed to load the test page when clicking on the relevant link. When the test starts, the web page displays the links and the requirements that users' computer should meet and in particular: **Adobe flash player** installed and the last version of **Java** are being required. Some difficulties occurred also during the installation of the products and due to that the students had to bring their computers in class and it was performed a group installation. It would be appropriate to make install the products by the students first and after that to message students' feedbacks regarding the e-tests, instead of adopting the opposite order of actions.

As per the messages received from the students, they had difficulties in answering the open questions, when it was required to write some formula, equations, some particular symbols etc. The system is based on different **Chemistry Editors**, based on **ChemSketch** and **MS Maths Editors**. Students learn how to work with **Math Editors in MS Office** since 9th grade, which presumes that in 11th and in 12th grade they shall be already able to write formulas with this system in an interactive dynamic environment. Due to the high percentage of students (76 %), who are unable to write formulas and graphics, the e-tests were modified and it was **allowed to attach up**

to 3 pictures format files to every open answer. Moreover, there is no limit in the number of attached files (**Require attachments**) or in their type (**Accepted file types**). The activated option **unlimited attachment files** is a disadvantage of the e-test, since allows students to apply pictures (scanned or shot) of the solution of some questions, written on a paper, which contradicts the principle of the electronic test – no use of paper and take the test at any time and place, even by using only a smartphone.

A very small number of students (7 in 30) have written some formulas, equations and graphics through Moodle's system.

Regardless the fact that there are no specific requirements about the format of files that can be attached to the answer of the open question in **Moodle**, the students tried to attach files that cannot be read by the **MS Office packet or Mac**, and some of them were completely unable to attach any kind of file. This is the reason why the students experienced some difficulties with the file uploading. Therefore 5 in 30 students had individual learning hours on the option "**attach a file**".

Till now, the students never took on-line tests and for this reason they experienced some difficulties during the first **Test – Thermochemistry**. The Moodle's platform is not integrated in theirs

schools, therefore the students have no experience with this type of examination and assessment. But this fact does not explain the enormous IT-illiteracy in terms of working with software application. Almost 78 % of the students are unable to install programs, to work with **Java Script, HTML, to work with chemistry and math software**, to follow operations algorithm when message is being displayed (**Alert and Help**).

There is an absence of basic practical skills that have been taught in Computer science and IT classes during the previous schools years. Therefore additional classes are required, in order to teach the students how to work with Moodle, in addition to more intensive Computer science and IT classes during the previous academic years. A functional illiteracy when using Information technologies was detected. Short courses of tuition classes of **MS Office, HTML, JavaScript and Math&Chemical Editors** were taught by the students. Unfortunately, it was registered a lack of knowledge in applied chemical software.

After the additional IT training, all technical problems were solved, therefore they did not occur again during the next e-tests - Kinetics, Catalysis, Chemical balance, Theory of Electrolytic Dissociation and Ion exchange processes.

At the end of the training a survey regarding students' satisfaction from the test was carried out. The results from the survey showed that all students were very satisfied by the conducted electronic tests and assessment. As a recommendation, the students advised that the electronic assessment and e-tests should be used also in public schools. In addition, 16 in 30 students have reported that thanks to the e-tests they had learned something new about Chemistry and Environmental protection and that they are going to use it in their practice.

CONCLUSIONS

It was successfully implemented a system (**question bank**) for electronic tests in Moodle (www.informacia.org) in Chemistry and Envi-

ronmental protection including Thermochemistry, Kinetics, Catalysis, Chemical equilibrium, Electrolytes, Ion exchange processes, Oxidation – reduction reactions units. The e-tests of Chemistry and Environmental protection were successfully performed, checked, it was made assessment and self-assessment in the web platform of **Moodle** (www.informacia.org).

This was the first time when students took electronic tests during their school education; therefore initially some technical problems occurred during the e-tests. At the beginning of the school year, the students experienced difficulties to use the educational platform of Moodle, regardless the IT classes taken at school. After a short IT training, the educational “gaps”, caused by the lack of knowledge in working with software and internet products were filled in.

At the end of the training the students were satisfied with the electronic tests as a part of the assessment and self-assessment process. They were curious about Moodle's possibilities to create e-tests and they wanted to be assessed through this method also in the public schools.

The new students' way of thinking requires new teaching technologies, as a natural progress of the learning methodology. In this case the electronic learning (e-learning) stands at the top of the teaching technologies in the contemporary pedagogy [10] as a part of the quality management systems. The e-tests are necessary at school as a result of the new type of students thinking – electronic, internet oriented way of thinking. The new electronic assessment and self-assessment replace the traditional didactics methods of paper assessment and self-assessment. The electronic tests fully satisfy the educational needs and attitudes of the contemporary students and its their preferred docimological method. In the light of the above, it will be appropriate to increase the number of schools that uses e-tests as a part of assessment and self-assessment method and to include and intensify the lessons of IT learning and Chemistry software at school.

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