THIRD HUMBOLDT CONFERENCE ON COMPUTATIONAL CHEMISTRY

Varna, Bulgaria
24 - 28 June 2006

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Editors:
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The picture at the cover is produced by Miroslav Rangelov with MolRan visualization program.

ISBN-10: 954-323-199-0
ISBN-13: 978-954-323-199-7
Avangard Prima
Sofia, 2006

Computer-Based Testing in Physical Chemistry Topic

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Purpose: Computer-based testing is use all over the world in many academic fields being considered an efficient and effective end-of-course evaluation methods comparing with classical written examination. The aim of the research was to develop and implement a computer-based testing methodology and to evaluate its effectiveness on the academic performance of third year student at Technical University of Cluj-Napoca.

Methods: The information discussed at courses and laboratory classes were transposing into multiple-choice questions and were included into an MqSQL database. The interface of the computer-based testing was created by the use of PHP programming language by integration of the multiple-choice questionnaire with the score methodology. The testing methodology includes: the place of the exam (at the test center, room C414), the type of examination (tutor assisted; thirty multiple-choice questions choused randomly from a total number of three hundred; checking out a radio-button correspondent to the correct answer), the impossibility of giving up after the test begin, and the score methodology (the correct answer coefficient - C_{ca}, the coefficient of time - C_t, and the testing score - $10*\text{sqrt}(C_t*C_{ca})$) and was assess on a sample of forty-two students. The students had the possibility to use the testing environment as many times as they consider being opportune.

Results: The number of testing varies from one (seventeen students, almost 40%) to seven (one student). The coefficients obtained to each testing were included into the computing of the final mark. The average of the mean of correct answers coefficients was 1.16 - 95% CI [1.01, 1.32] - for the whole sample, 1.13 - 95% CI [0.83, 1.43] - for female students and 1.17 - 95% CI [0.98, 1.36] for male students. The average of the mean of the coefficient of time was 1.34 - 95% CI [1.14, 1.53] - for the whole sample. No significant differences between the performances of male and female students on testing coefficients or testing scores were observed ($p > 0.05$).

Conclusion: This study demonstrates that the proposed computer-based testing methodology can be a real solution in end-of-course evaluation in Physical Chemistry, providing a less subjective and a less time consuming assessment method.

COMPUTER-BASED TESTING IN PHYSICAL CHEMISTRY TOPIC

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ABSTRACT
An automated computer-assisted evaluation system for student knowledge evaluation was developed and has been implemented at the Faculty of Materials Science and Engineering, Technical University of Cluj-Napoca. The system is available for students' end-of-course evaluation on physical chemistry topic. Instruction on use of the evaluation system is provided by the teacher which developed the system. The methodology, implementation, and evaluation of the system are reported.

INTRODUCTION
In universities, the cardinal premise of the end-of-course examination is to assess as objective as possible the students' knowledge and skills acquired on the courses, practical activities and seminars. Development of communication and information technologies [1] provide the opportunity of creation of interactive computer-assisted environments used in all domains including in chemistry training and evaluation [2].

PURPOSE
Starting from the experiences obtained from creation of the multiple choice examination system for general chemistry topic [3], the aim of the research was to develop and implement a computer-based automated testing methodology for physical chemistry topic and to evaluate its effectiveness by applying it on third year students at the Faculty of Materials Science and Engineering, the Technical University of Cluj-Napoca.

MATERIALS AND METHODS
In the development of an automated computer-assisted testing system three issues were followed: (1) creation the multiple choice questions banking, (2) development of the computer-assisted testing environment (see table 1 for specifications), (3) validation of the computer-assisted system (performed on a sample of forty-two undergraduate students).

Table 1. Methodological specifications

Item banking methodology
The item: Is construct as a statement or a situation
The options: are possible choices to address the situation (five for each item)
Levels of items: knowledge, comprehension, application, analysis, and/or synthesis
Number of items for subjects found in the curriculum: at least twenty -for (with one, two, three, and four correct answers)

Testing methodology, scores and marks methodology	
Place of the exam	At the test center, room C414
Type of exam	Tutor- and computer-assisted; Thirty multiple -choice questions choused ra ndomly from the database; Checking out a radio-button correspondent to the correct answer
Score methodology	$T_{score} = 10*sqrt(C_t*C_{ca})$ where T_{score} = testing score; C_{ca} = the correct answer coefficient; C_t = the coefficient of time
Final mark	Can took values from 4 (is the lowest one, the exam is not p ass) to 10 (is the higher mark); The lowest average of testing scores had associated the mark equal with 4, and the higher average of testing scores had associated the mark equal with 10

RESULTS
The computer-assisted environment on physical chemistry topic was created and it is available via the address:
http://vl.academicdirect.org/general_chemistry/physical_chemistry/.

The item banking contains a total number of four-hundred and twenty-four questions (see items distribution from table 2). The performance of the created system in automated generation of tests is presented in figure 1. For example, the items 108 and 424 did not appear in any test, while the item number 1 appeared in fourteen out of eighty-six tests (each test contained thirty items and associated possible options).

Regarding the students' evaluation, the coefficients and the final mark were computed for each student and were analyzed on the whole sample (see table 3). The results of testing the hypothesis that there were no differences between parameters obtained by female and the parameters obtained by male, for each parameter, indicate that in all cases the null hypothesis was accepted ($p > 0.05$). The distribution of final marks obtained by the students is in figure 2.

Table 2. The distributions of questions in item banking

Question	Number of correct option(s)				Total
	One	Two	Three	Four	
Number	209	114	70	31	424
Frequency (%)	49.29	26.89	16.51	7.31	100
95%$CI_{frequency}$	[44.34, 54.24]	[22.88, 31.37]	[13.21, 20.51]	[5.19, 10.38]	

Table 3. Averages and 95% CI associated with coefficients and mark parameters

	All students	Female	Male
C_{ca} (score coefficient)	1.15 [1.00, 1.30]	1.07 [0.80, 1.35]	1.17 [0.98, 1.36]
C_t (time coefficient)	1.09 [0.92, 1.25]	0.94 [0.78, 1.10]	1.13 [0.92, 1.35]
T_{score} (average of testing scores)	11.72 [10.45, 13.00]	11.43 [9.28, 13.58]	11.81 [10.22, 13.41]
Final mark	6.74 [6.24, 7.23]	7.11 [6.06, 8.15]	6.54 [6.02, 7.06]

Figure 1. Correct answers distribution from generated tests

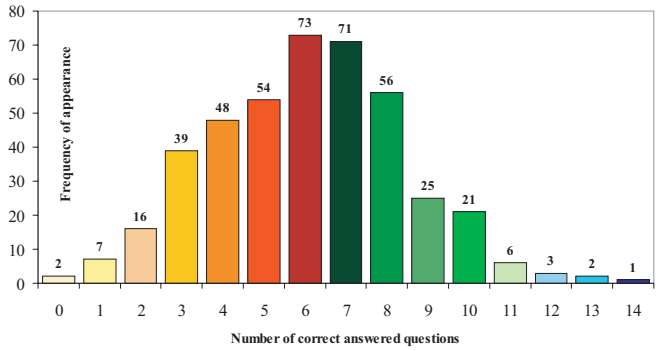
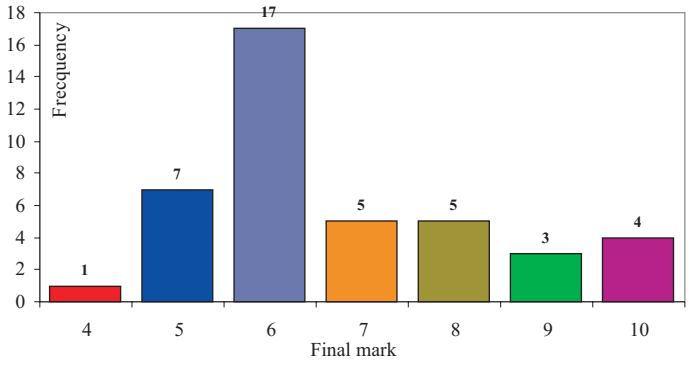


Figure 2. The distribution of physical chemistry final marks



CONCLUSIONS
Comparing the automated multiple choice computer-assisted evaluation with a classical examination type (as it is an essay) at least three advantages are obviously: the evaluation cover each subject from the curriculum, the assessment is more objective (the teacher could not be accused that was subjective in the evaluation), and the time necessary to give the final mark is significantly lower.
The proposed computer-based testing methodology and its implementation can be a real solution in end-of-course evaluation in Physical Chemistry, providing a less subjective and a less time consuming assessment method.

ACKNOWLEDGEMENT
Research was partly supported by UEFISCSU Romania through the project ET46/2006.

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