A Concept of the Web-Based E-Testing system

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Abstract: The paper is devoted to the development of a general web-based e-testing knowledge system (WbeTS) solution with optimal use of communication possibilities offered by the Internet. Developed conceptual solution: (a) enable frequent testing of many students with fewer teaching stuff, (b) allows each student the significant freedom of choosing the time, place and manner to do the test, and (c) provides the method for uniform evaluation criteria achievement. Introduction of the paper reviews and elaborates advantages and disadvantages of actual practice in testing and e-testing as well as written and oral part of final exam. Here it can be concluded that contemporary practice of the student examination is far more intensive than the former so it is necessary to increase the number of teaching staff or develop more appropriate examination systems. The second part considers different testing methods and possibilities of their application in the case of WbeTS. Further, the possibilities of the online and offline supervision of the students work are analyzed. The third part describes the development concept of WbeTS system. The diagram of the test routing is also presented – each student starts with the same block of questions, and the next block depends on the results of the first block: time spent, quantity, and quality of answers.

I. INTRODUCTION

Modern systems for e-testing and e-assessment, which are used separately or as a part of today's LMS (Learning Management System), represent a major step forward in the application of ICT in the educational process. However, despite the rapid development of ICT, e-testing in university teaching practice is still, more or less, unreliable supplement procedure for the assessment of student achievement, which is relatively often abused. The reasons for this are: (a) insufficient conditions for the implementation of effective e-testing [1] and / or (b) limited reliability of achievement assessment results, and (c) regulations that oblige teachers to a certain proportion of the oral examination.

Insufficient conditions limit the readiness, reliability and flexibility of e-testing and are stressful for students and teachers. Limited reliability of e-testing results is a consequence of insufficient quality of the whole group of questions and sub questions of systematic sampling, and more or less emphasized subjectivity of teachers in evaluations of student achievement.

According to the experience of teachers of the University of Rijeka, who extensively use computer aided systems and distance learning, among the biggest barriers to more intensive use of e-testing are: (i) insufficient capacity of IT classrooms for the implementation of e-testing, (ii) insufficient number of teachers and assistants required for monitoring the testing procedure, (iii) methodological limitations of e-testing. Methodological limitations of e-testing procedures are also the limitations of each written test, and are usually related to the inability to test higher levels of achievement, frequency of student cheating in tests, and a complex and lengthy process of evaluating the test. Because of these limitations, teachers continue to believe that the oral exam is still the final relevant tool for assessing levels of achievement.

It follows from above that the opportunities offered by ICT (Information and Communication Technologies) are still not sufficiently exploited and that e-testing systems and computer assessment of achievement are not in line with the requirements of modern teaching practices. Therefore it is necessary to direct radically the flow of development of e-testing to the exemption of strictly controlled conditions and to apply a more effective system of achievement assessment, which will make e-testing more accessible and less stressful for students, and more objective and more efficient for teachers.

II. MODERN E-TESTING

A. System and e-test methodology

Today's tools and systems for e-testing, whether they are commercial or free, consist of two main components [2]:

![E-Testing System Diagram](image)

Components of modern systems for e-testing must be based on theoretical propositions of contemporary quality items analysis (Item Analysis) [4] and modern psychometric evaluation of the response (Item Response Theory) [3].
In addition, a suitable system for e-testing must include: convenient user interface, reliable subsystem for authentication and reliable subsystem for authorization.

In this way, eventually the modern system of CBA (Computer-Based Assessment) will be formed, which can be used independently or integrated into the current LMS or VLE (Virtual Learning Environment).

An e-testing system should be commonly acceptable to students, teachers and institutions, therefore while working out its concept, it is necessary to bear in mind numerous requirements:

- **Compliance with the taxonomy of educational objectives** (learning outcomes) – tests, that is, questions that are used in e-testing should reflect the different levels of cognitive achievement, according to Bloom's taxonomy of educational objectives [5],

- **Compliance with legislation** which defines the procedures and rules for assessing level of achievement – assessment procedures are often regulated by specific legal acts, at the state level or institution level, in whose framework the e-testing must be conducted.

- **Compliance of questions and tasks (items)** with IMS-QTI standards (IMS Global Learning Consortium - Question and Test Interoperability Specification) - items used in e-testing should be compiled with the standards that define the display of content items and responses to e-testing [7].

- **Ability to integrate with existing LMS systems** - although systems for e-testing can function independently, they should be developed as modules of course management systems.

- **Simplicity and reliability in use by the teachers** - the system for e-testing is expected to have a simple and understandable teacher’s interface that has a reliable mechanism for the proper processing, interpretation and recording of statistical indicators of the items [8].

- **Simplicity and availability for use by the participants** - the interface of e-testing system should be as intuitive as possible for use, authentication and sending short and clear messages to the student, and the system should be designed so that it can be accessed from any computer connected to the Internet.

- **Security in the implementation of the testing procedure** - implementation of e-testing has to be safe and valid from the standpoint of:
  a) the e-test: authentication and authorization of the student, secure SSL (Secure Sockets Layer), monitoring network activity, safe access and storage of test solutions;
  b) s-process control testing: monitoring the physical activity of students, monitoring and recording computer activities during e-testing.

- **Effectiveness and efficiency** - e-testing system is designed so that it, ultimately, facilitates the reliable evaluation of achievements to teachers and students. So, after the expiration of the time required for development, customization and validation, and the necessary initial investment, the system should be more efficient and economical for implementation than the usual written verification of achievement.

In developing the concept for the implementation of e-testing procedures, that is, computer-based verification of accomplishments (CBA), scientific and technological achievements of the theory and examples of good practice and experience [9], [10] from the current field should be taken into account. CBA designed system should be an integrative part of e-learning within a VLE. It is easiest to follow the course of preparation and implementation of e-testing through the life cycle of questions that are used for e-testing; it includes the following steps:

1) **Analysis of learning outcomes and preparations for the test** - the teacher analyzes the cognitive level of learning outcomes that is expected from a learner, capabilities of the CBA system and, in collaboration with other professionals, creates questions for e-testing. One should not ignore theoretical, professional and pedagogical basis [11] needed for the successful development and implementation of testing. So, preparation for e-testing begins in compiling questions and determining the Minimum passing level (MPLs) [12] for each question.

2) **Delivery of e-tests** - tests are delivered through an appropriate interface that is used to collect test results. Access to the interface and implementation of testing should be safe and supervised. E-testing is usually performed as an online test.

3) **Assessment of achievements of e-testing** - evaluation of the e-testing results is carried out using the mechanism of e-testing, according to predetermined criteria. This means that in assessing the results the model for the evaluation of absolute assessment is used, that is, the achievement is compared with predetermined (standard) knowledge.

4) **Item analysis of the e-test** - evaluation of the test quality is necessary to determine the basic characteristics of the test such as: validity, objectivity, discrimination [11] and readiness, reliability and flexibility. The modern LMS systems include Item analysis (IA) which is calculated by statistical parameters such as weight and discrimination of items but do not explain the meaning of these parameters [8]. Results of IA are necessary for the correction of test results.

5) **Correction and revision of the e-test** - based on feedback from IA, it is necessary to perform correction issues and / or criteria for evaluating the results. Only after several successful audits carried out, a test can be declared valid and can be standardized for a particular area and at a certain time.

The current practice of e-testing is based more or less on these assumptions and criteria for the development and implementation of e-testing. Different systems for e-testing are distributed either as a standalone application or as a part of an LMS.
B. Problems of e-testing and possible solution

Although modern systems and e-testing procedures usually meet most criteria and settings from the previous chapter, test design and implementation of e-testing largely depend on qualifications and skills of teachers in its implementation. In order to eliminate the crucial influence of teachers, it is necessary to identify specific problems hindering the wider and better use of e-testing.

The first problem concerns the criteria relating to levels of cognitive objectives. This is also the issue of any testing procedure, and refers to the impossibility of a successful test of cognitive achievement levels on the more complex levels of knowledge application, analysis, evaluation and creation [5], [6]. The problem is the result of restrictions on items that can be applied in the tests and e-tests, and demanding categorization of some levels of issues. Items that are used in e-testing are mostly simple multiple choice questions, completions or true/false statements. This results in limited use of e-testing on partial knowledge test, elimination test and self knowledge test.

The second problem relates to the security of the implementation process of e-testing and the conditions in which it is performed. Due to limitations of the test items, there is a strong possibility of cheating in this process, so the test is carried out in controlled conditions and limiting computer labs. However, despite the strictly controlled conditions, cheating is still present. Direct consequences of this problem are: a limited number of subjects that can be tested in real time, problems in reservation of classrooms and computer time spent by teachers to supervise students. This formalizes the process of e-testing and an oral examination seems much more important segment in assessing the performance.

The third problem relates to item analysis. Item analysis, which is an integral part of modern LMS, brings the teacher a whole range of statistics on return items. These data relate primarily to the weight, discrimination, the frequency response. However, the system usually has no inbuilt mechanism to interpret the data to the creator of the test and to offer him suggestions on the correct decisions regarding the validity or actual cognitive level of the questions. The teacher or the creator of test must therefore spend a lot of time on the interpretation of item analysis and on the review of e-test.

The solution of these problems is possible by developing a new system of e-testing which will, with its concept and logic, affect on some of these problems directly and on some indirectly. The system is called WbeTS system and integrates the following: a hierarchical approach to testing, multimedia items, testing and online monitoring system and system for interpreting the item analysis.

A hierarchical approach to testing refers to blocks of separated questions (tests), divided by levels of cognitive achievement. This approach relies on modern types of multiple choice questions [20], and the possibilities of multimedia (text, audio, images) to resolve issues at higher levels of achievement.

Online monitoring mechanism is based on a modified system for remote detection and interpretation of motion [14], [15], [16], [19] which is, among other things, used for remote surveillance of elderly persons. By modifying these systems, it is possible to observe those critical movements of students that clearly could mean cheating in the testing: (a) prolonged loss of focus while using unauthorized materials, (b) absence from the place of testing (c) a conversation with another person. Such actions are called anomalies; they are determined by their weight and are written to the specified file. According to this record, depending on the criteria for testing, one can determine the validity of the test. The system uses visual authentication mechanism through a web-camera, based on [17] and [18], for preventing completion of the test by another person.

The interpretation of item analysis in WbeTS system consists of a mechanism which, on the basis of item analysis of the LMS and a predefined level of questions, suggests the validity and item level to the test creator. This mechanism provides an automatic (overall) or individual categorization and evaluation of the test questions.

C. Possibilities of WbeTS system

WbeTS concept of e-testing is designed as an integrative module of the e-learning system based on Moodle [13] LMS. This system, through a hierarchical approach to testing enables the evaluation of higher levels of achievement, and using sophisticated monitoring system eliminates the need for physical supervision of students by teachers during testing. This, ultimately, should lead teachers to focus their work to those tasks that are important in assessing higher levels of student achievement. Through the achievements, the system allows the teacher an unambiguous insight into the assessment level of the student, and to the student it enables the choice of target levels of achievement, more relaxed testing and, ultimately, it stimulates the student to achieve better results.

The basic idea of WbeTS is not to transfer the final assessment of students to the computer and to exclude the teacher from often tiring and stressful written and oral assessments of student’s knowledge. This system should provide the basis for the oral exam at the level of knowledge demonstrated by the student at the e-testing. Only after a brief final oral exam the teacher concludes the final grade for the student.
The system has been designed as an integrative part of the CMS (Content Management System), that is LMS system, and uses some important common elements of this system. These are: authentication and authorization, a bank of items and item analysis subsystem. It should be noted that additional multimedia types need to be added to the existing items in the future, and these types, due to the complex process of standardization, will need development and refining.

WbeTS system (Figure 1) consists of a programmable portion controlled by the teacher, the central system that manages the modules and evaluation processes, and Web sites to access and administrate the system. Modules of WbeTS system are:

- **Module - BASE**: This module is a database of questions appropriate for e-testing. Questions are classified into 5 groups that represent levels of achievement based on the modification of the revised Bloom's taxonomy of educational objectives [6]. The database entries are based on learning outcomes of each topic or topics, and when creating the questions, along with other parameters, determine the level to which they belong. The first three levels are very similar to previous systems of online testing and include the types of questions that are solved at the level of recall, playback, and simple logical connections and applications. Tasks 4 and 5 belong to a group of complex issues whose resolution requires a complex implementation, analysis, evaluation and creativity. Therefore, at these levels it is necessary to set the types of questions that include more complex procedures for their solving, and the complex, written and spoken, component of solutions presentation. So, on 4 and 5 levels, as an addition to the previous level, the possibility of a voice answering the question is introduced, as well as the storing of the entry and the link to the response base.

- **Module - CRITERIA** (settings): In this module the teacher determines the properties of questions, the conditions of transition to a higher level and the evaluation criteria. Characteristics of each questions level usually relate to the number and type of questions for each level and how they will be generated to the student (automatically or on request of teachers). The criteria for entering a higher level are the points collected at each level, needed to go to the next level, the time available to solve each level, and any possible request for tracking the movement of persons and participants during the testing via a web-camera. The evaluation criteria are related to the individual scores for each question and to achievement assessment in relation of the collected collective scores.

- **Module - WbeTS ENGINE**: This is a server application that monitors, manages and coordinates the work of all WbeTS system modules with LMS environment. This module provides access control and e-testing process, and at the request of the teacher or automatically performs actions relating to the classification level of the test, evaluation of achievement, interpretation of item analysis, statistics and reports. WbeTS engine controls the systems for security access, the monitoring of students' activities and the audio-visual surveillance of testing. It is directly linked with the modules Base and Criteria, used by the teacher to affect the mechanism. The use of the security protocols for access, the internal (optional) authentication, the activity monitoring on the computer, and disabling other activities on your computer during the test represent the basic level of security that is predefined for all levels of testing.

- **Module - INTERFACE**: This is actually a web interface through which teachers and students have access to the system. The interface consists of two levels: the teacher (administrator) and the student. Through administrative interface the teacher has access to the modules "base" and "criteria" and through them forms E-test and determines its course. Through this interface the teacher conducts experimental tests, carries out the evaluation of achievements, performs interpretation of item analysis, generates reports, monitors the implementation of the flow test, studies records (logs) on the implementation of testing, communicates with the participants, defines the visual appearance of the interface, etc. Student Interface is designed for accessing e-testing process, communicating with the teacher and monitoring the level of personal achievements.

PHP scripting language and JavaScript were used for the development of the core of the test WbeTS system. XHTML language was used for the Web interface design, whose layout is defined using CSS. Since the system is being developed as a part of the Moodle LMS ver. 2.x, guidelines, tools and existing open source code of the system were used for the development [13]. Plugins developed by independent programmers were used for testing [20].

IV. E-TESTING PROCESS IN THE SYSTEM WbeTS

The procedure of WbeTS e-testing (Figure 2) consists of 5 levels, which also represent the level of student achievement. Each level represents a separate entity after which the student can complete the test, or pause and continue at another time period, depending on the agreed implementation of the e-testing. During the testing, a
student can stop the testing at any time, and only the results of completed levels will be recorded.

The testing begins with access level 1. At this level there are questions and assignments from the database pertaining to the knowledge at the level of recall or recognition. It has a large number of simple multiple choice questions, gap-filling, cloze, and true/false questions. Only the factual knowledge is estimated here, concerning the terminology and specific details of the content. It is anticipated that the time required to solve this level is unlimited and without additional monitoring, but it is considered only a "ticket" in the actual evaluation of achievements. Rating after this level should match only the assessment of the FX, which would mean that the student is ready for testing for positive mark.

At level 2, there are slightly less questions than at the previous level, but their number is still large enough. This level includes lots of questions and tasks of recognition and conceptual understanding of knowledge. It contains a large number of multiple choice questions, gap-filling, cloze, true/false questions and scaling and ranking questions. At this level the knowledge of categorization, classification, principles and theories is tested. For this level, timing and control are the elements that should play a bigger role but, depending on the teachers’ discretion, they can be limited. After solving this level the student would, depending on the success, the number of attempts and time in which he solved the tasks, get grade D or E, Sufficient (2).

![Diagram of the testing process](image)

**Level 3** is characterized by an emphasis on applicable knowledge regarding the factual and practical knowledge of various procedures, algorithms and methodologies. This level includes more complex tasks and questions: multiple choice questions, multiple response questions, text input, numeric response, scaling, ranking etc. Access to level 3 should, with the default security settings, contain a minimum of additional video and audio surveillance of testing which will detect only the basic (rough) motion anomalies [15] in order to prevent trivial method of cheating on the test. These anomalies are the most common: conversation, leaving the computer for (rough) motion anomalies [15] in order to prevent trivial method of cheating on the test. These anomalies are the most common: conversation, leaving the computer for unacceptable time, reading the literature or using another computer (prolonged loss of focus). The time to solve the tasks at this level should also be limited to a measure that would guarantee to an average and prepared student a successful resolution. Accurate determination of the test duration at this level requires further experimental testing. Successful completion of this level brings the student grade C or Good (3).

Moving to level 4, the time needed for answering the questions should be a significant limiting factor. The number of questions is small and mainly focused on the analysis (and synthesis) of complex materials and contents which describe an occurrence, systems structure, situation, process, technology, incident. Questions should therefore be formed so that the students seek differentiation, organization and determination of characteristic elements of the subject of analysis. At this level complex multiple choice questions, matching, scaling, ranking, numeric input, text input are used, as well as short essay types to which the answer can be given not only using text but also using speech. Since the students are expected to give clear and concise answers, the volume of text and speech are limited to the maximum extent possible. The teacher evaluates these responses, in spite of certain possibilities of automation. At this level, the audio and video surveillance monitors the same anomalies as in the previous level but tolerance towards these anomalies is significantly lower, which ultimately means more stringent oversight. By successful completion of Level 4 the student gets grade B or Very Good (4).

The last level of testing, level 5, consists of questions which evaluate the highest level of achievement in the cognitive domain. At this level, the default material is usually estimated or new facilities and materials are created (generated, produced and planned), based on the tasks presented. At this level there should be a smaller number of modifications of complex multiple choice questions, numeric input, complex essay-type questions, input code, multimedia content, and voice input responses to questions. It is necessary that the time for solving these tasks is relatively short, considering that these are issues that are meant for the most capable group of students. Video surveillance, conducted at this level, can allow minimum movement and sound anomalies, referred to at level 3. Complete automatic evaluation of this level is not possible, but, as a rule, when a small group of students is in question, the time for evaluating the response should not be an aggravating factor. If a student successfully completes this level, he receives grade A or Excellent (5).

It is anticipated that the process of e-testing is performed as an online test from the location at which the student is, or, where there are minimum requirements for running tests. The minimum requirements for the implementation of testing are the personal computer with a Web browser, broadband Internet access and a web camera with microphone. Video (and audio) surveillance and monitoring activities on the computer are carried out through the system mechanism, automatically, based on an algorithm that monitors anomalies. The teacher does not directly supervise the testing. He or she only gets...
feedback on the acceptability of student’s activities during the implementation of e-testing and the level of knowledge achieved. The teacher generally accepts the result of computer-conducted first three levels, or by examination the text responses and by listening the oral responses, concludes which of the two highest levels a student has reached.

V. TROUBLESHOOTING BY IMPLEMENTATION OF WbETS SYSTEM

Since the test WbETS system has not been tested in a real teaching environment and all system components are not yet fully completed, it is not possible to display all the real difficulties which will be encountered by students and teachers in its use. However, with the development of the system, the problems that occur and what can realistically impose an obstacle for implementation can be indicated. These problems are as follows:

- Development of algorithms and mechanisms for remote surveillance - for the application of algorithms for real testing it is necessary to conduct a series of experimental verification, which would guarantee the reliability of this mechanism;
- Development and standardization of new items - for levels 4 and 5 it is necessary to develop new items that will allow verification of these levels;
- Developing a system for the interpretation of item analysis - the development of this mechanism is a lengthy process that requires validation in real conditions.

During the implementation process of e-testing there is a possibility of occurrence of two problems, which can be solved relatively easily:

a) The student has not conducted e-testing using WbETS system from a remote computer - students should be able to use the e-testing WbETS system in e-classroom under the supervision of an assistant,
b) The level of the students’ knowledge at the oral examination is significantly below the level of knowledge achieved in the e-testing using WbETS system from a remote computer - a student repeats part of e-testing with WbETS system in e-classroom, under the supervision of an assistant, to a lesser level of knowledge or equal to that achieved with the remote computer.

After implementing and testing the system in real conditions, it will be possible to identify all the additional technical, pedagogical and methodological problems.

VI. CONCLUSION

Today, the systems for e-testing are widely used but are accompanied by numerous problems, from the insurance requirements for the proper implementation of the test to a valid assessment of knowledge.

WbETS system is an evolving concept based on the theoretical and methodological preferences of Bloom’s taxonomy of educational objectives and achievements of modern computer and communication technologies. Methodology for e-testing and evaluation of achievements, which WbETS system offers, represents a deviation from current practice and understanding of e-testing, which should be more acceptable and more accessible and less stressful for students, and pedagogically and methodologically more effective for teachers and educational institutions. A hierarchical model of approach to e-testing, on which WbETS is based, is more transparent and clearer than the existing way of e-testing, and should, with appropriate standardization of individual level and mechanism of the system, give deeper insight into the real achievement and competencies of students.

Further work needs to solve many practical problems, from monitoring students’ focus on e-testing (with or without warning) to increasing the volume of automated assessment of the validity of text and speech.

It should be emphasized that the teacher concludes and always will conclude the final grade only after a short oral exam.

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