Implementation of e – forms of knowledge evaluation in the learning process

Ante Panjkota, Neven Pintarić, Josipa Perkov
University of Zadar
Department of Economics
Trg Kneza Višeslava 9, 23000 Zadar, Croatia
{ante.panjkota, neven.pintaric, josipa.perkov}@unizd.hr

Abstract: *Knowledge evaluation represents an essential part of education, or precisely of any learning process. In this paper we compared knwoledge testing results obtained through classical methods and through e-learning system Moodle. The tests were designed analogously for the sake of comparison across different types of parameters – the achieved results (test scores), total time for the tests realisation, time for test preparation, the total time for test evaluation, and the perception of e – test in relation to the classic one. The analysis was done on a sample of 130 students, and the perception test was conducted throught online survey questionnaire. The aim of this article is to determine the basic advantages and disadvantages of applying e – method for knowledge testing in relation to the classical method. Through the introduction of matrix of knowledge evaluation concept further guidelines in using e – forms of the knowledge examination in teaching process are proposed.*

Keywords*:* matrix of knowledge evaluation, e – tests of knowledge, complementarity of knowledge testing methods, e-learning

1. Introduction

Last few years many systems that support e–learning have been developed. Moreover, we can say that it is a system for e–learning and e–teaching [1]. In literature they are known as the Virtual Learning Environment (VLE), Learning Management System (LMS), Course Management System (CMS), etc. Capabilities of these systems are numerous [2, 3] and include a variety of synchronous and asynchronous forms of communication, content management, tools for knowledge assessment, student group administration, opportunities for conducting individual and group tasks, mechanisms for monitoring student activities and achieved grades, active participation of students in the design of content, integration of simulations, web conferencing, and many others [4].

The strategy of most higher education institutions in the world is the integration of these systems in the classical model of education or creation of fully operable higher education system in such virual learning environment [5]. Electronic tests of knowledge evaluation or computer based tests represent the basis for the realisation of previously mentioned strategies.

Bartley [6, 3] states that the possibility of checking and measuring output results (outcomes) is the main factor in the credibility of online courses. According to Moallem [7, 94] many studies show that there is no significant difference in learning outcomes that are expected in e-learning in relation to the classical face-to-face process.

In Croatia, within the project EQIBELT, activities were taken to prepare strategies and the implementation of e-learning for universities in Zagreb, Rijeka and Dubrovnik. Divjak and Ostroški in their paper [8] point to the necessity of implementing different methods of checking the set learning outcomes adjusted to the level of education and other pedagogical parameters in the exactly determined teaching periods in order to contribute to a higher quality of the teaching process together with other elements and implementation of new technologies.

Numerous authors have compared the classical forms of tests with the Computer Based (CB) tests, and according to Clarian and Wallace results of these investigations vary [9, 10]. A change in course structure leads to changes in the way of assessment and grading students' learning outcomes - Ehrmannu in [6, 3]. Comparing classical with CB tests, Moallem [7, 95] claims that online tests have greater potential in the complex real world. They are suitable for testing within a project as well as in progress-based estimations and are problem oriented.

Taking into account conclusions of the research previously carried out, we made a comparison of the results from classical test and test conducted via e–learning system Moodle. First of all a high degree of similarity between the two test forms had to be ensured. Thus it was possible to observe the results achieved on each test (test scores), the time spent for preparing and implementing tests as well as to determine time needed for evaluations of both test types. A survey questionnaire was used to test the level of computer literacy and the perception of e–testing in relation to the classical one.

The main advantages and disadvantages of each way of testing are identified and further guidance in applicability of the e–forms for the knowledge evaluation in the teaching process have been proposed by introducing the matrix of knowledge evaluation.

2. Theoretical framework for the knowledge evaluation

Knowledge evaluation represents an essential part of education, or precisely of any learning process. Theories of learning, teaching and related theories of knowledge evaluation are as diverse as the world in which we live [11], [12], [13], [14], [15]. Generally, learning can be defined as the process of acquiring knowledge, whereas knowledge is the ability of interpreting information contained in the set of data or of generating new information from the already existing data. *Knowledge can be correct or wrong, correct but useless, incomplete, etc. In practice, only the reliable, correct knowledge is of interest, because it allows us to solve the problem from a particular domain* [16, 38].

The process of learning takes place in various formal and informal ways. There are different degrees of formal education, and in this theoretical framework we take special interest in the system of higher education. In order to determine the efficiency of a learning process we need to define evaluable measures of learning performance. It is necessary to align these output parameters with the goals of learning, or it is necessary to provide such measures of performance that represent the level of goal acheivement in the best way.

2.1. Taxonomy of learning objectives

Taxonomy of learning objectives is the basic framework that we use when determining the expected and desired achievements of students by the end of learning process, and thereby also as a framework for knowledge evaluation in a broader sense. The first such taxonomy was suggested by B.S. Bloom in 1949, but it was not until 1956 that he published it with a group of collaborators [17].

Bloom' s Taxonomy includes six basic cognitive domains - Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Except for applications, all other domains (categories) are divided into a specific number of subdomains.

Categories are arranged hierarchically from simple towards the complex ones and from concrete to abstract ones. The taxonomy arranged in this way includes linear transition from lower to higher cognitive categories, or aquiring a certain level in the lower ones to create the conditions for the transition to the next category. Although over fifty years this represented the main taxonomy of learning objectives and the framework for the verification of knowledge, Bloom' s taxonomy was subjected to minor modifications in the past few years in order to eliminate its basic deficiencies – e.g. disagreement with the latest achievements in the field of cognitive and neuroscience, as well as the complexity in the analysis of learning goals and in the evaluation of various methods for knowledge testing [18].

We apply the upgraded Bloom' s taxonomy according to [19] as the basic taxonomy of objectives in education, learning and evaluation of knowledge. The improved taxonomy is two–dimensional with knowledge as the first dimension, and cognitive processes as the second. The knowledge dimension is divided into basic subcategories as in the original taxonomy (A. Factual Knowledge - Knowledge of terminology; Knowledge of specific details and elements, B. Conceptual Knowledge - Knowledge of classifications and categories; Knowledge of principles and generalizations; Knowledge of theories, models, and structures, C. Procedural Knowledge - Knowledge about subject-specific techniques, algorithms and methods, as well as criteria for when and what procedure to use) therewith Metacognitive knowledge (D. – knowledge of the cognitive processes which have been used in solving certain types of tasks) is added. The following cognitive processes are included 1. Remember, 2. Understand, 3. Apply, 4. Analyze, 5. Evaluate and 6. Create – respectively shown in the next figure (Figure 1).

	The Cognitive Process Dimension					
The Knowledge Dimension	1.	2.	3.	4.	5.	6.
A.Factual Knowledge						
B.Conceptual Knowledge						
C. Procedural Knowledge						
D.Metacognitive knowledge						

Figure 1. *2D Taxonomy of the learning objectives*

2.2. Matrix of knowledge evaluation

Methods of knowledge evaluation provide verification of the achieved level for previously set objectives of the learning process. If we take the previously presented 2D taxonomy of learning objectives as the basis it is possible to set up methods of knowledge verification as the third dimension. In this way we will get the so called 3D matrix of knowledge evaluation – i.e. a framework within which we can check which of these goals are met and to what extent, and vice versa with what method and to what extent an individual learning goal can be checked.

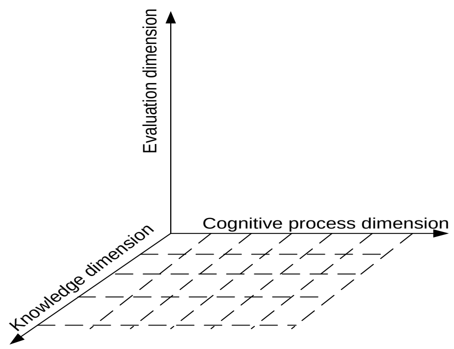

Figure 2. *Matrix of knowledge evaluation*

When setting up any kind of a framework for knowledge evaluation, the complexity of system and processes that will be estimated should be taken into account. In simple terms, an examiner and an examinee or a group of respondents are typical example of so called humanities and social systems, i.e. systems in which a man or a group of people play the central part, and as such fall into the category of extremely complex systems. All these systems are subject to the principle of incompatibility which states [20]:

> *„As the complexity of a system increases, our ability to make precise and yet nontrivial assertions about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exlusive characteristics.*"

The introduction of new technologies only increases the level of complexity of the system. This means that inadequate application of ICT in the system of education can easily lead to undesired consequences. Having this in mind the proposed matrix of knowledge evaluation is worth applying to all e- forms of knowledge testing in order to reduce the unwanted final outcomes of education to a minimum.

3. Methodology

Testing was conducted with 130 first-year-students of undergraduate study of Management – University of Zadar within the course of Information science. The course is one of the obligatory courses in the first semester. At the beginning of an academic year the course Syllabus is available for all students, in which they find, among other things, description of thematic units, the date and manner of test laying.

Testing was carried out in the eighth and fifteenth week of the first semester. The first part of the material was classical - paper based (PB) test and there were three groups (50 + 50 + 30) of students. In each group there were four groups of the test: A, B, C and D. Knowledge testing was performed in one day, with one hour interval between groups. Each test had 35 questions and included questions from the thematic sections that made up the first part of the material. The test writing time was limited to 45 minutes.

Creating questions for each thematic units was carried out through three days, generating test groups (A, B, C, D) on the fourth day, and preparing copies of the test on the fifth day. Test evaluation was conducted in the period of three days. Time needed for all mentioned actions was recorded.

Testing the second part of the material was done in the fifteenth week of the first semester and it was performed by Moodle - CB test. Till then students went through all the computer exercises specified by the course syllabus. In the first step questions bank was generated for every thematic unit of the second half of material. The question bank creation took place in the period of three days, and all mannualy recorded time measurements were compared with time registered through e–learning system. The system has the possibility of generating tests according to the settings specified by the course leader (Teacher) – there were 35 questions in the test, students had 45 minutes to do the test, each test was generated by the same principle, i.e. it contained the same proportion of questions according to thematic units. The option for the random questions "withdrawal" from each topic was set, while only a number of mandatory questions from individual units were specified. Enabling options for random question and answer ordering leads to a great variability of the tests - or simplified, in that way large number of groups are provided. Computer based tests were taken in the IT classroom in groups of 25 students, thus providing the same conditions for all. Testing was done in one day, and students had the insight into results after the completion of the test.

Perceptions of the e-test in relation to the classical one and the level of computer literacy were checked with a questionnaire survey. Statistical data processing was done in MATLAB program package using Statistical Toolbox and in Excel.

3.1. Prerequisites for PB and CB testing

Findings and results of previous research [9, 10], and the possibility of applying the CB tests in education [21, 22] were used as preconditions for this testing, and also for setting up methodological approach of the research.

In accordance with that, the PB and CB tests were prepared by analogous principles – they contained the same types of questions. The starting point were the possibilities of the Test module (quiz) in Moodle CMS. The following types of questions were used: a) Matching, b) Embedded Answers (SHORTANSWER and MULTICHOICE), c) True False d) Multiple choice. The same types of questions were used in the PB test. We provided high degree similarity of both tests - the same font and the same text pt size, with the same number of questions per page or screen. In this way, the conditions for the comparison of PB and CB tests were created - not for the sake of proving its mutual equivalencies, but rather for determining the advantages and disadvantages of each of them in the process of checking the acquistion of the goals defined by 2D taxonomies of learning objectives (Figure 1).

3.2. Questionnaire

The questionnaire consists of 18 questions that are divided into three categories. The first part relates to the possession of PC, acces to the Internet and time volume in which the respondents are used their computer.

The second part related to determining purposes for which students use their PC (searching the Internet content and Web browsing, communication, using Web and office applications, e-learning system).

The last category of the questionnaire referred to the perception of e-test. As in the second and the third part of the questionnaire students' opinions / attitudes were determined, they were given answers in rank from 1 to 5, where 1 was the lowest value and it had a negation value (no in general or never), whereas 5 was the highest value and it meant complete agreement with the statement.

4. Results and discussion

Our test group consists of f = 87 female, (66,92%) and f = 43 male (33.07%) students. Most students, about 75%, are 19 to 21 years old. They all have a computer at home, and only 12.8% do not have broadband access to Internet. The daily average of computer using is between 2 and 3 hours ($\bar{x}$ = 2,8, Mo = 3). The average time that students spend on using the e-content (http://ekonomija.unizd.hr) is 30 minutes to 1 hour ($\bar{x}$ = 2,46, Sd = 0,76). Knowledge testing via e-test is generally acceptable for 40.8% of students, 40% consider this way fully acceptable and only 3.2% do not accept this method.

The use of e-test is generally easy for 40% of students, 41.6% considered it completely easy to use, while only 2.4% of them have a completely contrary opinion.

The method of knowldege e-testing was generally easy to understand for 42.86% of students while 50% of students considered this method completely simple to understand.

The assessment of the e-test acceptability is in correlation of 0.46 with the estimation of its simplicity. The assessment of the acceptability of e-tests is in correlation of 0.42 with the estimation of simplicity of understanding these types of tests. The assessment of the simple use of e-tests is in the correlation of 0.50 with the estimated simplicity to understand these types of tests.

Students often pointed out the following disadvantage: e-testing generally does not provide the objectivity of test scoring (23.39%), while 19.35% consider that e-testing sometimes is not objective.

The average grade of comparison "e-testing is better in relation with previous classical testing" was 4.03 (3 = neither yes, neither not, 4 = mainly yes 5 = completely yes) with a coefficient of variation of 24.08%.

Looking at the level of their knowledge in the course „Basics of IT“ students scored on average a good grade (3) with a coefficient of variation of 13.48%.

The average score of students who passed the preliminary test by PB was 17.476 (out of possible 25) with standard deviation 2.311, and the average score on the CB test was 17.713 (max same as in PB) with a SD of 2.605. Preparation time, test realisation time, and evaluation time for both test models are shown in the following table (Table 1 & Table 2).

Table 1.: *Times for PB test*

	PB test (130 students)		
	preparation time	realisation time	reviewing time
Min	360	135	780
H	6,00	2,25	13,00
total time [h]	21,25		

Table 2. *Times for CB test*

	CB test (130 students)		
	preparation time	realisation time	reviewing time
min	480	290	60
h	8,00	4,83	1,00
total time [h]	13,83		

The evaluation time for the CB test mostly relates to time spent on evaluating responses to short type questions. Passing percentage on both tests was the same (76.2%). The identical values of 17.5 scores for the median are obtained in both test.

The results point out the high degree of similarity between the PB and CB test, almost identical success of students on both tests, as well as a very high degree of accepting CB testing method by students.

In addition, over 80% of students consider CB testing method simple to use, and over 90% of them generally rated it easy to understand. The only drawback for a larger percentage is the non-objectivity in the CB test. But the settings in the system are the same for every student. The system should ensure a high degree of objectivity in the assessment of CB tests, and for that reason further testings in that direction are needed.

The significant time saving is obvious in favor of CB tests, especially if we take into account the groups with a large number of enrolled students. Further time saving is especially possible in the CB test due to the question bank which can be very easily upgraded or modified in a short period of time.

5. Concluding remarks

High degree of similarity between PB and CB tests, almost equal grades in both test types, more than a high acceptability of CB mode of testing by students are the reasons why e-forms of testing, with every right, can be implemented in the teaching process. The basic characteristics of e-forms of testing is the possibility of generating a large number of various tests - a large number of groups, and thus the quality of the testing process increases.

Time saving is another reason that goes in favor of the introduction of such forms of testing, especially considering that it implies less paperwork for teaching staff.

In order to increase the quality of testing through CB tests the introduction of matrix of knowledge evaluation is proposed. In this way it could be possible to determine which methods should be used to test learning objectives, and it could be possible to determine what type of questions could be used to check specific knowledge and cognitive abilities defined by 2D taxonomies of learning objectives.

The implementation of the matrix of knowledge evaluation in modern e-learning system should reduce the unwanted outcomes to a minimum. In this sense, we consider further development of the proposed concept of the matrix of knowledge evaluation very useful.

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