Mixed Diagnostic Tests in Construction Technology of the Training and Testing Systems
Anna E. Yankovskaya, Irina L. Fuks, Yury N. Dementyev

Abstract — the problem of efficiency increase of students’ educational activity by formation of learning purposeful trajectory in computer systems is discussed. The construction of mixed diagnostic tests that are a compromise between unconditional and conditional components is used in order to develop blended education and training. It is proposed for monitoring and testing students’ knowledge, professional and personal skills and abilities, and designing learning trajectory of courses for every student. The technique for construction of mixed diagnostic tests that is based only on the experts’ knowledge about a problem area is suggested. This technique is applied to information technology course.

Index Terms — blended education and training, information technology, learning trajectory, testing strategy, tree of mixed diagnostic tests.

I. INTRODUCTION

The problem of efficiency increase of students’ educational activity has always been actual. It is especially important to control the process of training for lack of the teacher. Namely such way of activity is a part of the modern concept of blended education and training. The term “blended education and training” [1] is a relatively new one in educational practice: there were very few references to it till 2000. Despite its novelty for the education and training market any trainer should know that the blended education and training has always been the key point both at a higher school and a manufacture. Blended education and training represents the integrated training environment which combines the advantages of e-learning and traditional classroom teaching [2]. One of the main problems of higher school is to develop mechanisms for effective education and to train a large number of graduates who will be able to solve different tasks [3]. The simplest case of blended education and training is a learning process that is based on using diverse resources and methods within the structured and targeted syllabus. It is necessary to note that despite variety of information technologies (including artificial intelligent methods) they are not widely used in the interaction process of a teacher and a student for the diagnostics of gained knowledge. The development of such systems requires considerable labor efforts, time and cost [4], [5]. Students of different abilities have diverse preferences in the process of learning and reaching their goals. In [6], Lynna J. Ausburn used a questionnaire aimed to assess university students’ abilities such as initial level of their knowledge, skills, and experience. Orientation on student’s particular interests and capacities should make the learning process more effective and economic. Any specialist should rely on experience and skills obtained at a higher school to find the proper solution of educational and industrial tasks. Moreover, he should understand very clearly why and how he will use the obtained knowledge, professional and personal skills, and abilities to reach his goals. In their research [1] Bliuc, et al. identify four different ways in which blended learning can be defined. Blended learning can be seen as: a mix of modes of web based technology, or a mix of various pedagogical approaches, or a combination of any forms of instructional technology with face-to-face instructor led training, or a combination of instructional technology with actual job tasks (in order to create an effective mix of learning and working). The suggested computer technologies in training, learning and testing are based on the mixed diagnostic tests (MDT) [7]-[12]. MDT being one of the most adequate and useful tools is a compromise between unconditional and conditional components which expediently to use in blended education and training. As alternative to [7]-[12], we suggest using MDT to design the educational process trajectory. Diversity in the educational process (possibility to choose trajectory) is highly appreciated by students in blended education and training. For effective implementation of MDT approach we should solve the following tasks: a) offering students the instrument for designing their own learning trajectories, b) providing interaction of a teacher and a student, and c) increasing accessibility to information. We expect the process of education and training to be effective and economic as a result of this approach based on MDT.

II. PROBLEM BACKGROUND

The modern society involves dynamic, frequently unpredictable changes, which call for students and graduates to be able to solve different educational and professional tasks [3]. It should be noted that blended education and training calls to an extension of range of skills, experience and knowledge (competences) of both teachers and students. In [12], Yankovskaya proposed to use MDT, a new paradigm of intelligent systems development which is based on the test methods of pattern recognition. Using MDT in intelligent learning and training systems is more fully presented in [11], [13]. Unfortunately the methods of testing which are commonly used in Russia insufficiently motivate students on education and training. Blended education and training using MDT is an alternative attempt to the traditional educational approach, for example by providing flexible opportunity for the design trajectory of education. We hope that using MDT helps to overcome weak motivation of students and to
organize the purposeful approach to improving the quality of studied material during a semester. Any academic discipline can be represented as a sequence of sections. In order to formalize the description of the discipline structure it is common practice to match each section with a separate didactic unit. In the study and development of the course, the sequence of learning didactic units can be either arbitrary or dependent on the students' knowledge gained in previous studies of didactic units. MDT can account for this dependence at each grade level. In turn, the study of individual didactic units can also be represented by the sequences of independent or strictly successive elements of the course. Consequently, in the framework of the development of separate didactic units MDT can be applied.

III. BASIC CONCEPTS AND DEFINITIONS

The following concepts and definitions are used [11], [13].

Respondent - a person participating in testing.

Diagnostic test - a set of test tasks which serve to identify the course material the respondent failed to learn.

Mixed diagnostic test - a diagnostic test which is used to establish the sequence of test tasks based on the results of previous work. Testing of this kind is apt to show the respondent how to go into further study in case of irregularities or difficulties in learning the course.

Unconditional component (diagnostic) test (UCT) is characterized by the simultaneous presentation of all its constituent test tasks during the decision making.

Conditional component (diagnostic) test (CCT) is characterized by the sequential presentation of test tasks, depending on the assessment of the previous results.

MDT tree - the structure to display relationships between the different elements of MDT. The root node is necessarily correlated with the unconditional component of MDT. Each of the remaining nodes is associated with either unconditional or conditional component of MDT. Tree edges are set between nodes, i.e. between the different components of MDT.

IV. FORMULATION OF THE PROBLEM

This research is aimed at the process of creating MDT, and the strategy of its application using the didactic unit of the course “Information Technology” as an example is described. The issues dealing with electronic text documents are studied. The course “Information Technology” is included in the curricula of almost all of the bachelor degree programs. It is to be noted that the MDT construction should be performed by a highly qualified expert [8], [11] in the relevant area of concern, i.e. a specialist in the chosen academic discipline.

V. DESCRIPTION OF THE TEST STRUCTURE

Traditionally, the study of the discipline “Information Technology” at different faculties of many universities is completed by pass/fail grading test. Tests are developed and presented in the system “Moodle” [14]. Some of the test tasks used by the authors to create MDT are borrowed from the term grading test, which was offered to the students of Tomsk State University over a few semesters. Based on the test are the test tasks. The test task includes a question and a certain set of alternatives to choose from, or to form the correct answer. In the present research use is made of the following standard forms of test tasks: a closed form with either the only answer, a closed form with multiple answers, a matching test, a sequence test. Mastery test consists of 25 questions, each of them chosen randomly from a certain category of questions.

The test was assessed by the five-point grading system.

The results of a statistical analysis of test tasks provided by the Moodle are shown in Fig. 1. Statistical analysis of the test reveals that some test tasks have low discriminative efficiency for the control of knowledge. However, they may be useful in MDT for learning management, as their facility index shows the relative simplicity of some tasks and the complexity of others. MDT tree created for a specific topic, "The text processor Word", is shown in Fig. 2. The development of the chosen topic should form a system of the students' understanding of the technology of the electronic text documents, which will help in the future to freely navigate in a variety of specialized software systems. Note that the tree nodes are numbered. \( u_i \) in the number is used for unconditional components, \( c_i \) – for conditional ones. Table 1 shows the correspondence between the credit test tasks and MDT.

Of all the possibilities of Word the functions of a software system, which allow students to make properly an abstract or a course project, were selected. Therefore, included in the test are the issues related to the external design of the text, i.e. formatting. In the test tree 5 unconditional components were given. Education and hence testing must start with the first component - «Formatting». The next level of the test contains 4 unconditional components: «Symbol», «Paragraph», «Special Parts of the Document», «Automatic Document». On this level any of the unconditional components can be selected. On completion of test tasks of the unconditional component the average score is evaluated. Further testing based on the scores given is performed from the selected

<table>
<thead>
<tr>
<th>Question number in the test</th>
<th>The questions in the MDT</th>
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<tr>
<td>6</td>
<td>Paragraph - Attributes</td>
</tr>
<tr>
<td>7</td>
<td>Symbol - Attributes</td>
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<td>8</td>
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<td>Style, Standart styles, Standart Table of Contents</td>
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<td>Bibliography, Reference to a Bibliography</td>
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unconditional component to the conditional components associated with it. At each successive stage of testing one test task is given. It is assessed, and then advancing along the selected branch of the test tree is carried out. In case of failure in doing a certain task the respondent is redirected to the relevant section of the course for revision. If the respondent still can’t solve the problem, he might consult the teacher.

In the test tree, there are nodes, with several edges included, for example, «Outline» and «Headline’s References». These tasks can be brought to the execution only after passing all the higher branches of the tree. The proposed strategy of passing the test allows creating the final assessment as an integrated one in terms of the results gained at each level. The information, which in this case is fixed, can be used for the cognitive achievements analysis.

To describe the strategy of the test facilities and its software implementation, a tree node numbers of MDT shown in Fig. 2 will be used.

For each of the unconditional and conditional test components coefficients matrix of the answer correctness coefficients and the questions weight should be formed (Table 2) [13]. Rows of the matrix are associated with the test tasks given to the respondent while passing a test component, the columns – the numbers of respondent’s answers, where \( n \) – the number of questions (the strength of unconditional or conditional component of the test), \( k \geq 2 \) – the maximum possible number of different answers (in terms of correct and incorrect answers). Answers weight \( w_i \) must satisfy the condition \( 0 < w_i \leq 1 \) for any \( i \).

For closed test tasks with the only possible answer \( k \) is equal to the amount of the proposed answer variants. For closed test tasks with multiple answer \( k = \sum_{i=1}^{m} C_i^m \),

where \( m \) – the number of proposed answer variants. For the test tasks on establishing the correspondence between two lists \( k = l! \), where \( l \) - the length of the list. For the test tasks on establishing the correct sequence \( k = s! \), where \( s \) – the number of elements in the sequence.

The matrix element, which is at the intersection of the \( i \)-th row and the \( j \)-th column specifies the weight of the \( j \)-th answer to the \( i \)-th question. It is to be noted that the total number of answers to various questions may be different, and as a result, the matrix may contain empty elements.

Along with the matrix described for each component of the test the threshold assessment of learning material \( p_t \), where \( t \) - the number of MDT tree node, must be specified.
Fig. 2. Mixed diagnostic test tree
VII. DESCRIPTION OF THE TEST STRATEGY WITH SAVING RESULTS

In this example, testing always starts with the node $u_1$. The respondent is given all the tasks in this part of the test. The respondent's answers are recorded as a pair $i$, $j(i)$, where $i$ - the number of the question, $j(i)$ - the number of the selected answer to the $i$-th question. This information will help then fully reconstruct the process of passing the test by each student. According to test results intermediary assessment is calculated $E_{ui} = \left( \sum_{i=1}^{q} a_{ij(i)} \times w_i \right) / n$.

Based on the use of elements of fuzzy and threshold logic the score is compared with threshold value $p_u$, after which there is an appeal to any other unconditional test component which is determined on the MDT tree, or recommendations to the re-study of the relevant part of the study material are made [10], [11], [13]. Similarly, every other component of the unconditional test is tested. The differences start up when advancing along the test tree reaches a node with a conditional component. The concept of MDT assumes that only one question is selected from the conventional components of a test and by its answer the direction of traversal about the test tree is determined. The respondent’s answer is fixed as a pair $i$, $j(i)$, where $i$ – the question number, $j(i)$ – the number of the chosen question. By test results intermediary assessment is calculated $E_{c_q} = a_{ij(i)} \times w_i$ and then it is compared with the corresponding threshold value $p_{c_q}$, where $q$ is the number of a chosen conditional component. After that there is appeal to the other component which is determined on the MDT tree or recommendations to the re-study of the relevant part of the material are made. It should be noted that if there are several questions concerning the set of conditional components in the course material, they are supposed to be equal and in testing only one of them is chosen at random. Since the evaluation of test results is produced for each traversed node of the test tree, the total score is gradually accumulated and if necessary, testing can be interrupted at any level, with further renewal of stopping. The final grade can be both quantitative and qualitative if a mutual agreement between qualitative and quantitative scales is specified. An important advantage of MDT is the ability to use intermediary and final results of testing for the cognitive analysis. The visual scheme of educational achievements can demonstrate the progress in material learning and can serve as an additional means of teaching motivation.

VIII. CONCLUSION

The concept of a mixed diagnostic test consisting of a compromise between unconditional and conditional components is introduced. The technique for the development and application of mixed diagnostic tests, which is an element of technology of teaching-testing systems, is suggested. Actuality of mixed diagnostic tests application in blended education and training for estimation of knowledge, professional and personal skills and abilities is shown. A combination of elements of fuzzy logic [10] and threshold functions [13] for the knowledge assessment on the base of mixed diagnostic tests is used. The use of MDT can effectively manage the activities of the trainees in the process of curriculum development through the formation of targeted recommendations on building learning paths, which reduces the time and cost expenses for the organization and management of the educational process. Due to the fact that MDT can actually replace the teacher as a consultant, it is possible to use this approach within blended education and training [13]. The technique is illustrated in the training course "Information Technology". It is planned to apply the methodology to the development of MDT for other courses with different internal structure. Eventually, this approach might be used as well in the practical sections of technological disciplines of engineering education, for example, in the course "Mathematical modeling of electromechanical systems". MDT can be formed in such a way that it would serve as a teacher to explain the procedure of solving complex practical problems.

REFERENCES


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