APPLICATION MIXED DIAGNOSTIC TESTS IN BLENDED EDUCATION AND TRAINING

Anna E. Yankovskaya 1,2), Mikhail E. Semenov 3)
1) Professor, Tomsk State University, 36, Lenina pr., Tomsk, 634050, Russia,
2) Professor, Tomsk State University of Architecture and Building, 2, Solyanaya pl., Tomsk, 634003, Russia,
ayyankov@gmail.com
3) Associate professor, Tomsk Polytechnic University, 30, Lenina pr., Tomsk, 634050, Russia,
sme@tpu.ru

ABSTRACT
Relevance of computer based learning and testing of students are discussed. 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 control, monitoring students’ knowledge, professional and personal skills and abilities, and designing learning trajectory of courses for every student. We suggest a technique for construction of optimal mixed diagnostic tests that is based only on the experts' knowledge about problem area.

KEY WORDS
Intelligent pattern recognition, tree of mixed diagnostic tests, learning trajectory, blended education and training.

1. Introduction
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 of graduates large number 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. The blended education and training toolbox contains a different approaches and resources including the following: webinars, conferences, videos, virtual reality & simulation, gamed technologies, etc. 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. Development of such systems requires considerable labor efforts, time and cost [4, 5].

Students of different abilities have diverse preferences in process of learning and reaching their goals. In her study of [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 a 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.

At their research [1] Bliuc and etc. identifies 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 form 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.

In difference from the research presented in the publications [7-12] we suggest using MDT to design of the educational process trajectory. Presence of variety in the educational process (possibility to choose of trajectory) is highly appreciated by students in blended education and training.

For effective implementation of MDT approach we should solve the following tasks: а) 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 that a 
process of education and training will be effective and 
economic as a result of this approach based on MDT.

2. 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 her paper of [12], Yankovskaya proposed to use 
MDT which presented 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 the 
publication [11].

Unfortunately the methods of testing which are 
commonly used in Russia motivate students on education 
and training too poorly. Blended education and training 
using MDT is alternative attempt to the traditional 
educational approach, for example by providing flexible 
opportunity for the design trajectory of education. We 
hope that using MDT allows to overcome weak 
motivation of students and to organize the purposeful 
approach to improving the quality of studied material in 
during a semester.

3. Designing Learning Trajectory of Course 
using MDT

A number of various models are used to monitor and 
provide students' and graduates' knowledge, professional 
and personal skills and abilities [7-9, 13].

We have sequence of different courses and sections 
(topics) for each course. The number of courses during a 
semester is defined by an expert (or group of teachers). 
The complexity of courses based on credits of each 
courses. A student can choose a form of education and 

Diagnostic test (test) is the set of grouped 
characteristic features (and/or the characteristic features). 
Test can to distinguish any pair of objects (respondents, 
students) to different classes respectively.

Unconditional component (diagnostic) test (UCT) is 
characterized by the simultaneous presentation of all its 
constituent features of the object (respondent, student, 
discipline) during the decision making.

Conditional component (diagnostic) test (CCT) is 
characterized by the sequential presentation of features, 
depending on the value of the previous features.

We suggest that a test is diagnostic test, if as a result 
of its passing students access the correct result and 
detecting test if the only available outcome. The students 
receive the descriptive characteristic after passing of the 
test.

Figure 1. Example of the mixed diagnostic tests (MDT) search tree

Decision-making about a student's level of knowledge, 
professional and personal skills and abilities is carried out
Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Fuzzy logic began with the 1965 proposal of fuzzy set theory by Lotfi Zadeh. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. Despite traditional logic theory, where binary sets have two-valued logic true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. We use four gradations of fuzzy logic variables: poor, satisfactory, good, and excellent.

An expert must a) order the courses sequence by time of learning, and b) partition sequence of sections for each course into two subsets. The first subset includes the unconditional component of the mixed diagnostic test, i.e. sections of course (grouped characteristic features) that are introduced to students at random sequence. An example of search tree of MDT is given in the Figure 1. Root node of the search tree is associated with unconditional component of the mixed diagnostic test (sections 1, 2 and 3.1). Submission of a grouped characteristic feature of the second subset (conditional component test) depends on what the previous feature was presented on an appropriate level of the search tree MDT. Each branch of the tree represents an admissible sequence of actions to select the section that leads to a leaf. In addition, each leaf associates with the result of the test passage (Figure 1). It should be noted that order of features at the same level of the search tree does not matter. Bypass of the search tree branches is performed from left to right direction.

The conceptual circuit of MDT construction for the education and training is represented on the Figure 2. Test questions are corresponded to rows of the table represented in the top part on the Figure 2. Test questions are given to a respondent (student, graduate) at passing the unconditional component of the test. An answers on each question are corresponded to columns of the table. In this case n is a number of a question, k is maximum number of various answers to every question, where n is power of an unconditional component of the test. Some cells of the table can be empty.

The element of the table $a_{ij}$ is weight of $j$-th answer to $i$-th question, $0 \leq a_{ij} \leq 1$. The average weight of the answer on all questions is calculated as a result of passing of an unconditional component of the test.

Let $p$ ($0 \leq p \leq 1$) is a level of learning by the respondent of tested course or didactic unit. If a respondent has received preassigned value $pr$ ($0 \leq pr \leq p$) for the given course or didactic unit he is admitted to passing conditional component of MDT in case of training, otherwise a respondent is not admitted to passing conditional component of MDT. This component is represented on the graph allocated on the bottom part of Figure 2. Indexing questions of the conditional component of MDT is begun with number one. To each edge of a graph is matched the weight $w_{ij}$ which corresponds to complexity of a question where $i$ is a number of conditional component level and $j$ is a number of edge at the current level of conditional component.

A test question corresponds to each node of a graph $v_{ij}$
which a respondent should answer on and where \( i \) is a number of level and \( j \) is a number of conditional component node at current level. After passing of a conditional component of MDT each respondent receives an estimation of his knowledge, professional and personal skills or abilities.

Thus a respondent can get the following estimations of his knowledge: result is poor, result is satisfactory, result is good, and result is excellent.

A respondent has to study the material on course section once more on which the value of average weight of the answers on all questions is low that preassigned value \( pr \) in the case of training. Let's notice the test is considered successfully passed if the boundary \( pr \) is achieved. This boundary \( pr \) is defined for each course individually.

Only two levels of the conditional component of MDT is represented on Figure 2. In practice the quantity of levels is defined by the interval of time for performance of education or training.

4. Illustrative Example

We will give an illustrate example of the construction of mixed diagnostic test for the university course "Computer Science" ("Informatics") which takes 200 hours per semester (students specialization – Industrial and civil construction).

To construct the MDT we will use the requirements of Russian Ministry of Higher Education to compulsory of the educational programs minimum content. The main sections of course (grouped characteristic features) are follows:

1). The concept of information;
2). A general description of the data collection, transmission, processing and accumulation of information;
3). Hardware and software implementation of information processes;
4). Decision models of the functional and computational tasks;
5). Algorithms and programming;
6). High level programming language;
7). Database;
8). The software and programming technology;
9). Computer graphics;
10). Computer practice.

Each grouped characteristic feature contains a different number (from 4 to 8) of didactic units (characteristic features).

An unconditional component of MDT includes grouped characteristic features of sections 1-3. Note that grouped of characteristic feature (Section 3) should be parted into two: "3.1. The technical tools to implement information processes" and "3.2. Software implementation of information processes". A conditional component of MDT includes grouped characteristic features of 3.2, 4-9.

An example of search tree of MDT is given in the Figure 1. The numbers of the course sections are written in tree nodes (represented by rectangles). Objects assigned with the unconditional component of MDT (sections 1, 2 and 3.1) are listed in the root node of the tree. Transition to knowledge control on course sections which relate to the conditional component of MDT is provided if the student has successfully completed the task on the unconditional component of the diagnostic test if he scored at least 50 percent of correct answers. Branches of tree are marked by letters a, b, and c on arcs coming out of the root node (Figure 1).

During the construction of MDT a possibility to skip of a section is excluded and students are invited to explore the section which the study of sequent next sections depends from. Full sequence of branches tree search for the section 3.2 is shown only in the Figure 1. Thereafter the respondent (student) may proceed to carry out assignments from section 4 or 5. Similarly on tasks for sections 4 and 5 he can proceed to implement the tasks of the sections 3.2 and 5 or 3.2 and 4 respectively. One of the possible variants of the conditional component of the test is the following admissible sequence: 3.2, 4, 5, 6, 8, 7, 9. Applied part of course from section 10 may be indirectly is presented in each of the sections 1-9 as the practical tasks.

The tree leaves are represented as ovals. The test results were compared to the tree leaves. The tree edges marked with dashed arrows indicate the possible transitions of passing a conditional component of MDT.

The technology based on the application of the MDT for training and testing students' knowledge was tested by prof. A.F. Terpugov at the Faculty of Informatics and the Faculty of Applied Mathematics and Cybernetics of Tomsk State University (Russia). This technology has demonstrated efficiency of training and testing students’ knowledge in higher school.

5. Conclusion and Future Investigation

Actuality of mixed diagnostic tests application in blended education and training for estimation of knowledge, professional and personal skills and abilities is shown.

MDT technology used in blended education and training will increase efficiency of acquiring knowledge, professional and personal skills of students.

In difference from the research presented in the publications [1-6, 13] we suggest in this paper using a combination of elements of fuzzy logic [10] and threshold functions [14] for the construction of mixed diagnostic tests.

Improving quality of education is a main problem facing any higher school. Blending education and training is proposed to solve this problem with using the intelligent system which is based on test methods of pattern recognition.

The concept of a mixed diagnostic test consisting of an optimal combination of unconditional and conditional components is introduced. The background, basic concepts and definitions, formulation of the problem, the
method of a mixed diagnostic test construction are given. The purposeful choice of test tasks for monitoring procedure of students’ knowledge with using MDT allows to reduce time for carrying out learning, training and testing and to motivate students on studying didactic units during a semester.

Application of fuzzy logic and threshold function increases accuracy and quality of an estimation of respondents (students). Also this approach increases effectiveness of blended education and training by choosing the shortest ways to get the correct result and exclude the possibility of achieving it at random path.

This blended approach will be used for learning, training and testing students of different courses, for example, mathematics, informatics, geoinformation systems, etc. Also we suggest using MDT technology for the learning trajectory creation of different educational programs in a higher school.

Acknowledgements

This work was financially supported by Russian Foundation of Basic Research (projects № 10-01-00462а, 11-07-98015_r_sibir а) and MSE Program “Nauka” (contract № 1.604.2011).

References