Biometrics Technologies, Intelligent Library and Tutoring System within the EURASIA Project

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Abstract

The aim of this paper is to study the contribution of the new technologies (Search Engine Rankings, Multi-variant Optional Module Design and Multiple Criteria Analysis; Voice Stress analysis, IRIS recognition) to Intelligent Library and Intelligent Tutoring Systems. The article briefly describes use of these newest technologies in e-learning. The authors of the article have developed a voice stress database, which contains students' answers given during an examination, and a specific algorithm, which is a core of the Voice Stress Analysis Subsystem and which can evaluate a student's knowledge by giving a rather precise mark after a psychological test performed prior to the examination. A similar research of IRIS recognition technologies is being performed successfully. Practical application of the Biometrics Technologies, Intelligent Library and Tutoring System within the EURASIA Project is briefly analysed in the paper.

Keywords: EURASIA Project, Intelligent Library and Tutoring System, Voice Stress analysis, IRIS recognition.

1. Background

The EURASIA (EURopean and ASIan Infrastructure Advantage) Project is being carried out with the financial assistance of the European Union under the Asia-Link Programme. EURASIA project aims to enhance the capacity of the partner institutions for training, teaching and research activities required for the creation and long-term management of public and commercial facilities and infrastructure. One of the main activities includes development of a professionally accredited postgraduate curriculum, and design and delivery of training courses. In order to increase the efficiency and quality of delivery of the above-mentioned training, teaching and research activities, an Intelligent Library and Tutoring System within the EURASIA Project (ILT-EAP system) was developed. The features of ILT-EAP system include the search for and finding of useful material, multi-variant optional module designs, multiple criteria analysis and selection of the most rational alternatives of teaching material according to students' requirements. The personalized scenario is dynamically generated with emphasis on the requirements of each student. Besides, the System combines concepts of voice stress analysis and IRIS recognition technologies.

2. Intelligent Library and Tutoring System for the EURASIA Project

Search engine rankings have been adopted in most advanced intelligent libraries (Alexandrov [1], Gutwin [5], Hsinchun [6], Kaklauskas [7], Ruch [10], Trnkoczy [11], Wang [12]) and tutoring systems (Armani [2], Brusilovsky [3], Day [4], Lucence [8], Pouliquen [9]). As part of the ongoing Illinois **Digital Library** Initiative project, research proposes an intelligent personal spider (agent) approach to Internet searching, which is grounded on automatic textual analysis, general-purpose search and genetic algorithms (Hsinchun [6]). Pouliquen [9] use parsing techniques to extract information from texts, and provide a proper semantic indexation which is used by a medical-specific **search engine.** Day [4] use the Jakarta Lucene full text indexer to index full texts of textbooks. Jakarta Lucene is a high-performance, fully-featured text search engine library written entirely in Java. Its technology is suitable for nearly all applications that require full-text searches. It is also readily available and has a good API for our needs. ITA [9] index chapters, sections, and subsections of textbooks. Highlighters are used to highlight the index context. Finally, the ITA provides reading recommendations for students via a chapter similarity function. However, intelligent libraries (Alexandrov [1], Gutwin [5], Hsinchun [6], Kaklauskas [7], Ruch [10], Trnkoczy [11], Wang [12]) and intelligent tutoring systems (Armani [2], Brusilovsky [3], Day [4], Lucence [8], Pouliquen [9]) with search engine rankings cannot select chapters (sections, paragraphs) of a specific text, which are the most relevant to a student, cannot integrate them into learner-specific alternatives of teaching material and cannot select the most rational alternative, i.e. cannot develop alternatives of training materials, perform multiple criteria analysis and automatically select the most effective variant. However, an Intelligent Library and Tutoring System within the EURASIA Project (ILT-EAP system) can perform the aforementioned functions. No-one thought of the above function before, so this attempt is the first. The approach helps students to obtain suitably tailored material for an e-learning course. The above and other improvements are possible by using the ILT-EAP system.

A lack of optional alternative modules provides lesser opportunities to satisfy students' needs. Students, who gain basic knowledge in their field, often lack knowledge necessary for specific work. Students usually waste too much time in finding useful study material. Discovering the most rational study material among all that is available in a vast number of modules can have more meaningful outcomes for students. The main objectives of our work is development of the methods, algorithms and ILT-EAP system for searching and finding useful material, carrying out multivariant optional module designs, multiple criteria analysis and selection of the most rational study material alternatives according to students' requirements. Also the ILT-EAP system combines concepts from voice stress analysis and IRIS recognition technologies.

The ILT-EAP system consists of nine subsystems: Domain Model, Student Model, Tutor and Testing Model, Voice Stress Analyser Subsystem, Iris Recognition Analysis Subsystem, Subsystem of Multivariant Optional Module Design and Multiple Criteria Analysis, Database of

Computer Learning Systems, Decision Support Subsystem and Graphic Interface. The Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems and Graphic Interface are quite similar to existing Intelligent Tutoring Systems. The Voice Stress Analyser (VSA) Subsystem, Iris Recognition Analysis Subsystem and Multivariant Optional Module Design and Multiple Criteria Analysis Subsystem are innovative Intelligent Tutoring Systems solutions. VSA and Iris Recognition Analysis Subsystems are briefly analysed below.

3. Voice Stress Analyser Subsystem

The muscles of a human throat vibrate in a range of 8-12 Hz and this range is called a micro-tremor. When a person is emotional or stressed the vibration shifts from 8-9 Hz to 11-12 Hz, and the more intensive the stress the higher the frequency of such vibrations. The Voice Stress Analyser Subsystem (VSA) measures stress in a human voice. The research aim was to compare data received during an examination with ILT-EAP (information on correct and incorrect answers, time periods for each question, and the number of times a student changed an answer to each question of a test) with similar data received from the Voice Stress Analyser (VSA) Subsystem, to make practical conclusions and to plan future research. This research helped to determine changes of students' psychophysical conditions during examination. During an e-test, students were asked to select one correct answer from the provided alternatives and to say the answer aloud. The sound record of each answer was then saved into a PC memory with an identification code for listening and further analysis. Records were analysed by using the VSA Subsystem and the frequency range of micro-tremors for each specific answer to an e-test question was determined. Higher frequency of voice vibrations was determined when analysing voice answers to "unknown/difficult" questions. It was found out that the emotional stress of a student was higher when answering "unknown/difficult" questions.

The reliability of the results was assessed by making a correlation analysis of emotional stress and of evaluations of correct answers (in percent) to test questions. The analysis showed that a correlation exists between emotional stress and the correctness of an answer. During the experiment, a total of 4,000 voice records in four student groups were examined and analysed. The research helped to determine whether questions can be classified (in respect to students) as "known/simple", "unknown/difficult" and remaining questions in-between these two groups. Higher than average emotional stress was experienced when answering the "unknown/difficult" questions, and zero or minor emotional stress in case of "known/simple" questions. Having analysed the whole set of answers, a direct relationship was noticed between the emotional stress and the correct answers (in percent) to an e-test. During the research, the average micro-tremor was calculated for each question. Part of the results is shown in Figure 1.

Figure 1 shows the relation between a student's correct answers and the average micro-tremor frequency of the answers to test questions. The x-axis shows numbers of the test questions for students who were passing the examination. During examination, students had to mark and to say aloud the right answers to 20 questions within 10 minutes. The left side of the y-axis shows the correct answers (in percent). The right side of the y-axis shows the average micro-tremor frequency of each student during the examination. Besides, the Figure 1 shows two correlating curves obtained during the research; they show the direct relationship between the correct answers and the average micro-tremor frequency.

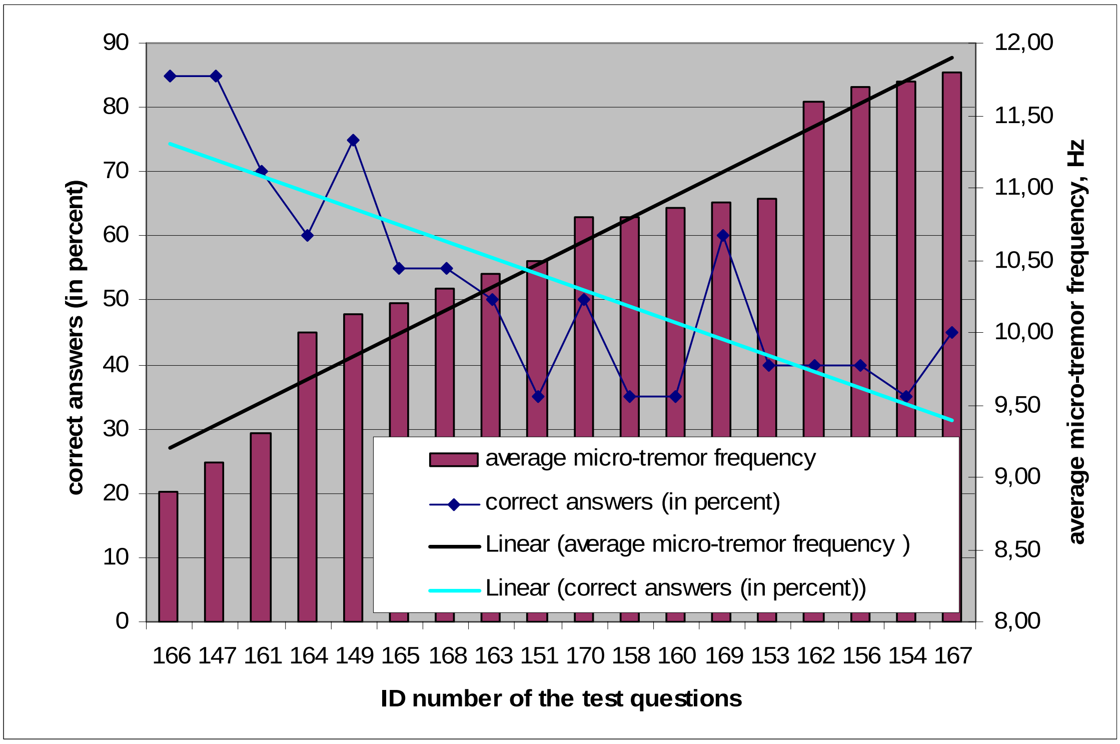


Figure 1: Correlation between the emotional stress and the correct answers (in percent) to the e-test: the x-axis indicates the numbers of the test questions, and the y-axis indicates the average micro-tremor frequency (Hz) in the student's voice (on the right) and the correct answers (in percent) (on the left)

Currently students' knowledge can be automatically assessed (instead examination) by using VSA Subsystem on the basis of student psychological tests, accumulated historic voice stress data, determined regression equation and special developed algorithm. The VSA Subsystem automatically assessing a student's knowledge before examination according to the student's spoken/oral answers. For example, when a teacher gives a student such 9 questions as "Are you well-prepared for the exam?," "What mark would you give to your knowledge?", "Have you learnt everything?", etc. before examination, and the student can be assessed quite precisely by giving a mark by using VSA Subsystem (special developed algorithm). Figure 2 illustrates the comparison of the marks given to students during the e-psychological test performed prior to the examination (using the Voice Stress Analysis System) and of the marks given during the examination itself (using the Intelligent Testing Subsystem). The regression-correlation curves seen in Figure 2 show interrelation between the marks given during the e-psychological test and the marks given during the e-examination itself.

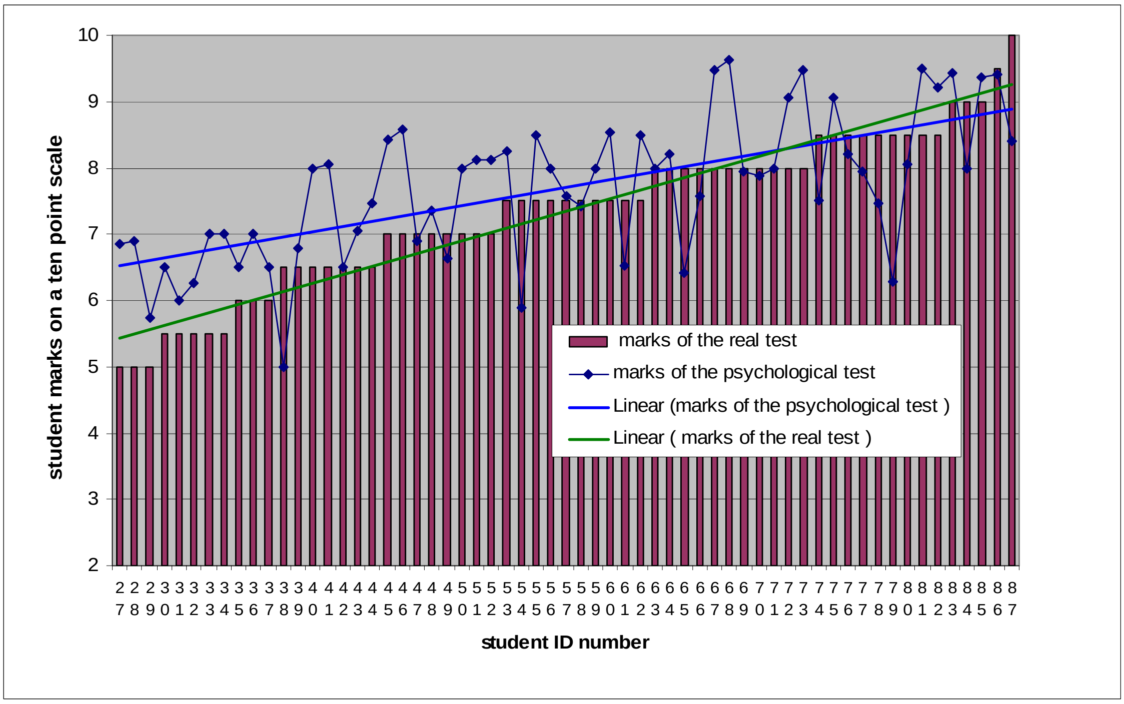


Figure 2. Comparison of the marks given to students during the e-psychological test prior to the e-examination and of the marks given during the e-examination itself

Legend:
y-axis: marks of students on a ten-point scale;
x-axis: students' IDs;
<u>"marks of the e-psychological test"</u>: marks given to students during the e-psychological test prior to the e-examination using the Voice Stress Analysis System;
<u>"marks of the real test"</u>: actual marks given to students during the e-examination using the Intelligent Testing System;
<u>"linear (marks of the psychological test)"</u>: regression-correlation linear trend, which describes the marks given to students during the e-psychological test prior to the e-examination using the Voice Stress Analysis System.
<u>"linear (marks of the real test)</u>": regression-correlation linear trend, which describes the actual marks given to students during the real e-examination.

4. Iris Recognition Analysis Subsystem

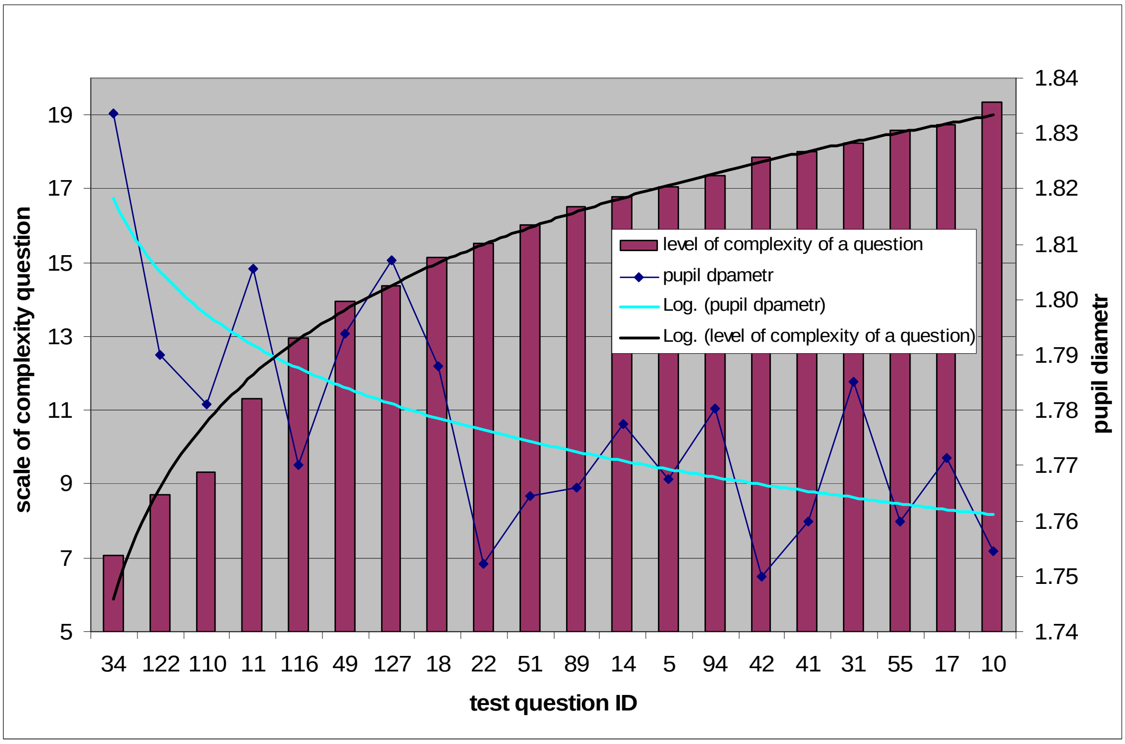
Students, sitting at a computer during the exam, were invited to answer 20 questions. It was a multiple-choice test. The questions were classified according to their complexity: from the easiest to the most difficult. The complexity of a question was determined according to the percentage of the students who answered it. Most of the students gave correct answers to the easier questions. Certainly, each person has a different opinion of what a difficult question is. However, previously, data has been collected and statistically processed, on the grounds of which such levels of complexity were determined, taking into consideration the exam results of the majority of students.

Currently, the research is in progress, and the interdependence between the changes in the eye iris diameter and the emotional state of a person is being investigated. During the research, a micro video camera, which records the changes in the diameter of a student's eye iris and transfers the data to the computer, is mounted in front of a student. Employing special software, an iris is photographed every three seconds and the results are saved in the PC hard disk drive, in separate files. Employing the *Matlab* software environment and adjusted scripts, the eye iris diameter is calculated from the video pictures, and the recorded changes are saved in the database. A database was obtained as the final result, where the students' answers to the e-questions and information about the changes in the iris diameter during the exam were stored.

All the students were provided with the same questions. Answers had to be given in 15 min. During the exam, the changes of the eye pupil were recorded by a video camera fixed on the head. Photos of a pupil were taken every three seconds in order to determine the moment of the change in the diameter as precisely as possible. Another step was to measure the diameters of all the pupils. Eye pupil is then digitised and stored in a PC database of enrolled students. The whole procedure takes less than a few seconds, and can be fully computerized with voice prompts. Moreover, while a student was answering, the time when the student progressed to another question and when he/she pushed the button to choose the answer was recorded automatically. The taken photos were matched to the provided questions with reference to the time, and the average pupil diameter was calculated. Thus, a pupil diameter is determined, which corresponds to a particular question, e.g. if a student was thinking for one minute before answering the question No. 1, then all 20 photos are taken (as the eye was photographed every three seconds), and the average of measurements is deduced. All the 20 pupil diameters corresponding to 20 questions were determined by such a sequence. According to them, it was possible to determine the student's reaction to each provided question. The changes in the eye pupil of some students were very clear and obvious (the pupil diameter might have changed by up to 5,5 mm); in others, the changes were insignificant (5,25 to 5,35 mm). We may draw a conclusion that those students, whose pupil diameter underwent minor changes, were better prepared for the exam, they worried less and questions did not seem so complicated to them.

The research helped to find out, whether an actual interdependence exists between the correct answers (in percent) and the changes in a pupil diameter. Figure 3 depicts the dependence of a pupil diameter on the correct answers (in percent). The *x*-axis indicates the ID numbers of the questions answered during the e-test and the *y*-axis indicates the average of a pupil diameter (*on the right*) and the correct answers (in percent) (*on the left*). In case a student answers all the questions correctly, he/she may collect a maximum of 20 points (100 percent). Figure 3 also shows two correlated curves obtained during the research that indicate direct dependence of correct answers (in percent) on the changes in a pupil diameter.

Figure 3 shows that the more complicated was the provided question the bigger the diameter of a pupil was. It widened most when answering the question No. 34. And actually, only 7 people out of 20 answered this question correctly. We may draw a conclusion that this question was most complicated. Moreover, a reciprocal process may be observed: the easier the question (more students answered it) the smaller the diameter of a pupil is. Figure 3 obviously shows that the assumption was proved. The higher the pressure a person experiences (uncertain of his/her knowledge or sees the question for the first time) the wider the pupil of his/her eye becomes and its diameter increases.



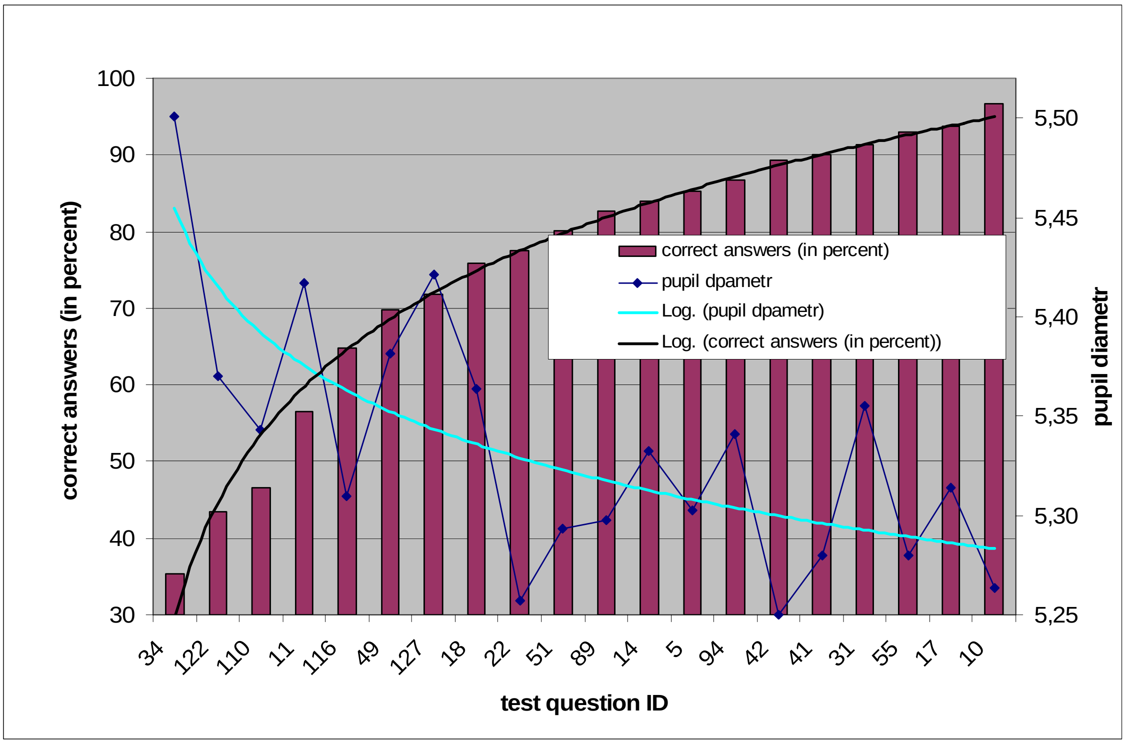


Figure 3: Dependence of a pupil diameter on the correct answers correct answers (in percent): the x-axis indicates the numbers of the test questions, and the y-axis indicates the average of a pupil diameter (on the right) and the correct answers (in percent) (on the left)

Supposedly, in the future, student's knowledge will be evaluated automatically taking into consideration the obtained data and determined interdependences. For example, a lecturer gives several questions to a student about the level of preparation to the exam, and the Iris Recognition Analysis Subsystem, with regard to the changes in the average of the student's eye iris, and taking into consideration the obtained data as well as determined interdependency, will be able to perform an automatic evaluation of his/her knowledge.

5. Conclusions

EURASIA project aims to enhance the capacity of the partner institutions for training, teaching and research activities required for the creation and long-term management of public and commercial facilities and infrastructure. One of the activities includes development of an Intelligent Library and Tutoring System within the EURASIA Project (ILT-EAP system). Authors of the paper applied the new technologies (Search Engine Rankings, Multi-variant Optional Module Design and Multiple Criteria Analysis; Voice Stress analysis, IRIS recognition) in the development of ILT-EAP system. The current features of the developed ILT-EAP system include the search for and finding of useful material, multi-variant optional module designs, multiple criteria analysis and selection of the most rational alternatives of teaching material according to students' requirements, application of biometrics technologies, etc. Future research intends active application of other biometric technologies (pulse measurement, blood pressure, biometric mouse, etc.) in e-learning. Also the future of this research is to study how to implement the new e-learning technologies (Search Engine Rankings, Multivariant Optional Module Design and Multiple Criteria Analysis, Voice Stress analysis, IRIS recognition) in e-teaching of MSc and PhD students of construction and real estate sector according to the objectives of the EurAsia Project.

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