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Web-Based Distance Learning System with Adaptive Testing Module*

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User models are essential to e-learning systems, giving students learning continuity, tutors the evidence of students' progress, and both a way to personalize students' learning materials according to their abilities and preferences. Personalizing information has long been the motivation behind developing e-learning systems. Adaptive educational systems attempt to maintain a learning style profile for each student and use this profile to adapt the presentation and navigation of instructional content to each student. This kind of system adapts the learning process on the basis of the student's learning preferences, knowledge, and availability. One such Web-based tool is built at the Business School of Professional Studies in Blace (the system of intelligent evaluation using tests), which infers student knowledge using adaptive testing. The knowledge will not be evaluated according to fixed standards, but it will depend on individual characteristics of each student. This system will enable the aforementioned school to modernize education.

Keywords: student profile; adaptive system; adaptive testing; learning style

1. Introduction

According to alfanet [1], adaptability in the context of e-learning represents the creation of students' experiences under different circumstances (personal characteristics, pedagogical knowledge, his/her interaction, the result of the previous learning process) in a certain period with a tendency of increasing the predefined criteria of success (efficiency of learning: result, time, the price, satisfaction of the user, etc.).

Adaptation can take three forms [2]:

(1) Adapted systems—the system is customized to a particular user profile, which is defined beforehand at design time; because the system is adapted to the person, i.e. the user, this type of adaptation is called personalization.
(2) Adaptable system—adaptation is explicitly required by the user. The user can specify preferences by manually creating a profile; thus the system is dealing with a fixed profile, which can only be modified by user's intervention.
(3) Adaptive systems—in which adaptation initiative belongs to the system itself, based on continuous observation of user preferences and needs. The user's profile is no longer static; it is dynamically updated by the system, after tracking and analyzing user behavior.

An adaptive web-based system is helpful for personalization. The structure of the web site and the learning strategies are two important issues involved in web-based learning; courseware designers need to pay close attention to how web based courseware is constructed in the curriculum as well as how learners navigate through it [3].

Personalization criteria are:

(1) Adaptability according to the level and goal of learning (criteria for choosing the difficulty level of the lecture plan, and criteria for choosing a different volume of the lesson plan).
(2) Adaptability according to the student's behavior and habits (criteria for choosing different ways of presenting the lessons and according to which you can choose different entry points as starting points for learning the lessons, related to the order by which reading, watching or listening is performed in the presentation).
(3) Adaptability according to modalities of learning and students preferences (criteria according to which it is possible to choose different ways of presenting the lessons: from basic textual presentation to rich multimedia effects in presentation).
(4) Adaptability related to interface adjustment according to the needs (administrator, student, and teacher) and preferences (design of web interface: color, font, resolution, etc.).

Adaptation decision in adaptive web-based systems is based on the user's characteristics represented in

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the user model, which should be based on cognitive theory and educational methodology [4].

Managing a certain student profile is the basic requirement for creating the adaptive behavior and for providing support for adaptive learning.

Adaptive educational systems attempt to maintain a learning style profile for each student and use this profile to adapt the presentation and navigation of instructional content to each student.

According to Benadi [5] when you consider the profile of a student, you have to take into consideration cognitive characteristics which fall under different categories: sensory affinities (verbal, spatial, logical, mathematical, kinesthetic); cognitive styles (impulsiveness/reflection, dependency/independency); personal characteristics (introvert personality/extrovert personality). Moreover, people have different learning styles as they take in and process information.

As well as functionalities included in most LMSs such as content authoring, delivering learning content and activities to students, discussion forums, administration of classes and groups of students, schedule planning, and many more, many systems provide additional features —automatic evaluation of knowledge (fixed, randomly, adaptive). One of the most important usage of e-learning systems is ability to evaluate or assess the knowledge of a student.

Testing is directly related to education and training as a way to measure the performance levels of students. Measuring student learning is always a challenge no matter what the delivery format. Teacher choices are limited by time, resources and creativity. Different methods of assessment have been used in different contexts, but the most common tools are oral test and paper-and-pencil test. Given that the computer has been an educational tool in the last few decades, there are a number of benefits in using computers for assessing performance [6]: large numbers can be marked quickly and accurately, students' response can be monitored, assessment can be offered in an open-access environment, assessments can be stored and reused, immediate feedback can be given, assessment items can be randomly selected to provide a different paper to each student.

Software tools and web-based sources are frequently used to support the learning process, so it seems reasonable to use similar computer-based technologies in the assessment process.

In this paper, the starting point is the fact that the traditional model of knowledge assessment does not have enough influence on the motivation for success. Namely, the teacher does not content himself with ranking students according to their knowledge but wants to show with the grade how they are different from each other. The suggested model of knowledge assessment should emphasise success as the final experience, because teachers should establish the requirements which only determine positive goals.

1.1 Using a computer for student testing

Giving grades is usually conducted in a traditional manner, through oral exams and written tests. However, today there are a great number of tests for learning and grading which can be done over the computer. Computer tests are a very efficient method of knowledge evaluation. The time of knowledge evaluation and issuing results is shortened. In reality, at the moment when the student finishes the test, the system generates a report (grade, or percentage, and some systems also recommend learning fields where students did not answer the questions well, etc.).

Numerous testing systems do not distinguish between individual characteristics of each student, neither from the aspect of assessment, nor from the aspect of expression; all students are treated in the same manner, i.e. they do the same tests. Moreover, the classical knowledge evaluation model does not sufficiently influence the higher success motivation.

Considering the fact that the process of individualization is strengthening in many aspects of human development, we suggest a model which is based on knowledge assessment through adaptive testing, where knowledge will not be assessed according to constant and unchangeable standards for its participants. The motivation behind our research was to develop a flexible system which works according to a teacher's decisions and student performance (student differences in prior knowledge, competencies, learning style, communication preferences, cognitive style . . .). It was based on success as the final experience because teachers are required to set requests which lead only to positive goals. In that way the main disadvantage of distance learning will be overcome—teacher/student contact.

Computer tests offer a great method for testing students' knowledge but they are not the only method applied in the school. Assessment can be based on writing an individual paper, preparing a group presentation, class participation, attendance, homework problem sets, and so on. Alternatively, when a student performs a task rather than taking a test, it is called performance assessment. Examples of performance assessment include:

- debating a topic;
- demonstrating a skill;
- conducting an experiment and writing the results;
- doing a project;
- compiling a portfolio of work.

Performance assessment at the Department for Computer and Information Technology is done in the Web laboratory, while student verbal expression and writing skills are tested through various forms of written assignments. These written assignments as a method of testing student knowledge are out of the scope of this research paper .

2. Literature review

User models are essential to e-learning systems, giving students learning continuity, tutors evidence of students' progress, and both a way to adjust students' learning materials to their abilities and preferences. Personalizing information has long been the motivation behind developing e-learning systems.

Few attempts have been made to model user cognitive and affective attributes in order to achieve system adaptability according to the needs of individual user. And while researchers agree on the importance of adaptation for user cognitive and affective characteristics, there is "little agreement on which features can and should be used and how to use them" [6].

Guidelines and examples of content adaptation and presentation depend on various learning styles in combination with instructional design theories are presented in [7]. Lessons are designed based on combinations of educational material modules, supporting several levels of adaptation towards individual learning style. Paper [8], gives guidelines for preparing learning materials according to different learner's characteristics, based on pedagogical strategy and the motivation factor with a strong psychological background, applying categories of Kolb's learning styles.

The most generic ITSs (Intelligent tutoring systems) architectures cover building a good student model that reflects system beliefs about a learner's mastery level in certain concepts. Moreover, such architecture is based on different domains, pedagogical strategies and enables systems to perform individualized tutoring for learners [9].

Intelligent tutoring systems may outwardly appear to be monolithic systems [10], but for the purposes of conceptualization and design, it is often easier to think about them as consisting of several interdependent components. Researchers have identified five major components. Note that four and five cover two related research issues, namely, how to represent domain knowledge other than facts and procedures, such as concepts and mental models, that can easily scaled up to larger domains:

(1) the student model—which stores information that is specific to each individual learner;
(2) the pedagogical module—which provides a model of the teaching process;
(3) the domain knowledge module—which contains information the tutor is teaching;
(4) the communication module—which controls interactions with the learner, including the dialogue and screen layouts;
(5) the expert model—which compares compares the learner's solution to the expert's solution, pinpointing the places where the learner had difficulties.

The goal of most ITSs is to use knowledge about the domain, the student, and about teaching strategies to support flexible individualized learning and tutoring. There are three core ITS technologies [11]:

(1) curriculum sequencing—provides the student with the most suitable individually planned sequence of knowledge units to learn and sequence learning tasks (examples, questions, problems, etc.) to work with;
(2) intelligent analysis of student's solutions—deals with a student's final answers to educational problems no matter how these answers were obtained;
(3) interactive problem solving support—provides a student with intelligent help on each step of problem solving.

With the Internet's evolution, researchers have attempted to deploy ITSs on the Web. These Web-based systems retain most generic ITS architecture features, such as AH (Adaptive Hypermedia), which generates content with different levels of detail according to users' knowledge. In addition, Web-based adaptive and intelligent educational systems (AIESs) have begun adopting and benefiting from AH technologies.

2.1 Some ITS systems

INSPIRE [12] is an adaptive system that monitors learner activity and dynamically adapts the generated lessons to accommodate diversity in the learner's knowledge state and learning style. The system is both adaptive and adaptable, as it allows the learner to control the interaction and provides guidance or help. The knowledge level and the learning style of the learner are used for the appropriate selection of lesson contents and presentation of the educational material. The learning style of each individual learner is recognized through submission of the appropriate questionnaire by the learner. This information can be used for the dynamic adaptation of the instructional strategy adopted for presentation of the educational material during a learner's interaction with the system.

iWeaver [13] is an adaptive e-learning environment that aims to address individual learning styles. It was experimentally evaluated with TAFE multimedia students to investigate the effect of media choice. This approach was implemented by creating an environment that provided learners with a choice of media experiences, rather than a static experience. The findings of the evaluation indicated that media choice has a negative effect on learning gain for participants with a high level of interest and prior experience, and media choice has a positive effect on learning gain and motivation for participants with a low experience level.

PERSO (PERSOnalizing e-learning system) [14] is a system where learners with different learning goals and aptitudes are treated differently by building a model of knowledge and preferences for each of them. This model is used to offer learners a personalized course fitting their needs. It is based on a questionnaire in which responses can be free text statements and it has a natural language processing mechanism that can robustly understand student input. Two types of information are used: the student knowledge about the course to be taught and student media preferences.

SIETTE [15] is an example of a Web-based adaptive testing system. System intelligence is based on two well-founded bases: the item response theory (IRT) and the computer adaptive testing theory. The only kind of learning material it possesses is questions. The system generates an adaptive sequence of questions to assess student's knowledge.

Developing e-learning systems that adapt to a student's learning style is not a trivial task. Design and development include selecting the appropriate learning style model, creating course content consistent with the various learning styles, determining the level and degree of adaptation of domain content [16] and creating appropriate tests for each student according to knowledge level and learning style.

In comparison with previously mentioned systems, our system has certain limitations.

Regarding the PERSO, student answers to the system's questions are not expressed as a free verbal statement and the knowledge representation isn't a form of semantic network.

System, through appropriate tests (student selects one of multiple choice answers), may determine the best learning style for a student and recommend the use of media for which a student shows most affinity, but does not dynamically adapt the generated lessons to accommodate diversity in a learner's knowledge state and learning style. Although the teacher designs the teaching materials, the student decides on material choice.

The effects of used teaching media on learning are still being investigated. Teaching materials catering for different levels of knowledge are being designed, which may take at least a year.

Our system is a web-based education system with a module which enables web-based adaptive testing. Therefore, it isn't complete AIES.

On the other hand, the systems advantage is reflected in the possibility of a fast and efficient student testing with immediate feedback. Participants with a low experience level may complete the test on a positive note by being offered test questions appropriate to their knowledge level. On top of that, the system offers an individually tailored test for each participant, more consistent examination process in the case of different examiners, a higher level of test security (since it is not known which questions the individual student will get), the ability of adapting time and acquiring a wide range of different question types, and giving precise results for the examined students with a wide range of knowledge. And in the end, the subjectivity of the teacher, which may be really emphasized during verbal examination and marking, is completely annulled.

3. Methodology of implemented solutions

This paper describes a Web-based LMS system ADES-TS (Adaptive/Adaptable Distance Education System—Testing System) [17] developed at the Business School of Professional Studies in Blace, Serbia [18]. The three—layer system architecture was utilized with Microsoft's ADO.NET technology, C# programming language and MS SQL database.

The user's profile is dynamically updated by the system, after tracking and analyzing user behavior. Regarding the process of testing, the system is adaptive as no user is evaluated with the same test (system supports the delivery of user-specific content questions).

This system is adaptable because it allows the user to change certain system parameters (with no system initiation) and adapt their behavior accordingly [19]. Users select from a variety of learning materials and use them to satisfy their needs. Regarding the process of testing, the system is adaptive as there is no user control.

As with other standard LMSs, the system has several groups of tools for use by students and/or instructors. The most important sets of tools are for student assessment, collaboration support for student groups and class management.

The profile of the student should be developed in order to get the system to adapt to the student while it is being implemented. The profile should contain information about the student, the level of knowledge and competence, his/her ability to conduct different activities, psychological and other charac-

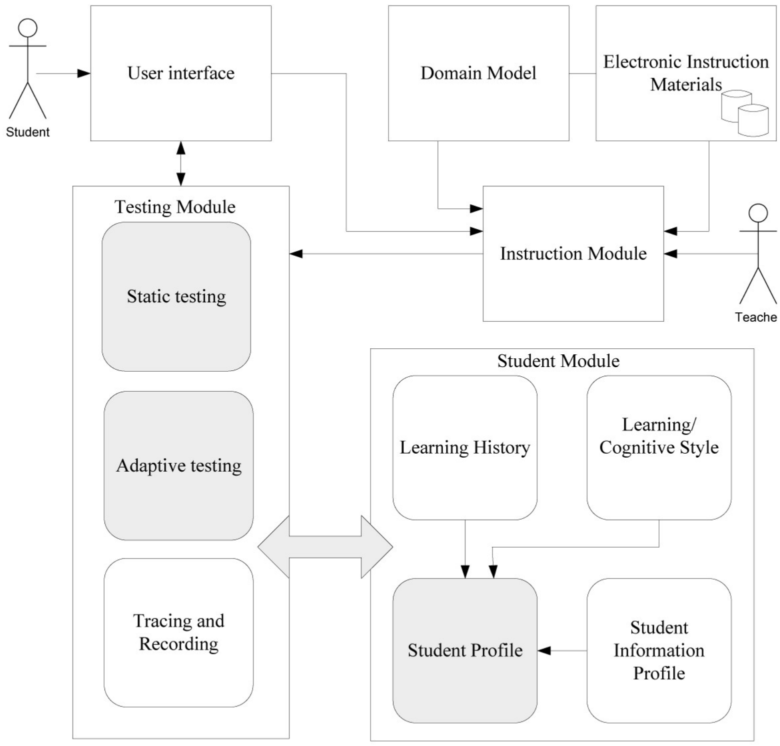

Fig. 1. System modules.

teristics necessary for organization of the adaptive process of learning [20]. The profile should also include parts which are necessary to be defined in order to organize successful lectures: learning styles, prior knowledge and experience, instructional goals, performance related information (e.g. results of exercises), layout preferences, current work and inferred future plans, emotions or intentions and the level of attention and interest. Accordingly, the flow and format of learning materials are adjusted.

One of the advantages of computer-based learning systems is their flexibility. These systems do not allow the student full control over the learning process but includes the teacher in the process by supervising the student's actions. The structure of the system is scalable and enables managing a larger number of students and courses. The system consists of these modules: instruction module, student module and adaptive testing module (Fig.1).

3.1 Instruction Module.

The basic course is distributed online in different forms: as a text (doc and pdf format) and as a multimedia course (presentation with audio and video file and simulations). After each traditional lecturing, the teacher directly and automatically places teaching materials on the system. The system enables authorized students to have access to all previously taught courses and lectures. This form of publishing enables the student to follow missed lectures over the Internet.

Instructors can modify their teaching styles to accommodate the learning styles of all, or at least the majority of the students in their classes. When a lecture plan is created, it is desirable that the teacher includes as many media, reflecting different learning styles, as possible. The basic idea was that some forms of instruction are more effective for students with certain compatible characteristics than for students with non-compatible characteristics. Thus, students can select between various types of teaching materials: textual (hyper-text), visual (image, diagrams, graphs, video, slideshows), aural (sounds, streaming audio) and kinesthetic views (animations, simulations) (Fig.2) and learn depending on their preferences. Giving students a choice can increase their control over the learning process. Therefore, the presented model of learning is adaptable.

In order to continue investigations regarding the influence of different media on learning process, the designed course materials were based on Fleming's VARK Model; it is suitable for visual, aural, read/write and kinaesthetic —a VARK learning styles.

Within the Teaching Module, a web laboratory was designed [21]. First, it simplifies the teaching process for the teachers and secondly it enables students an easier access to practical studying. The web laboratory is mainly dedicated for computer

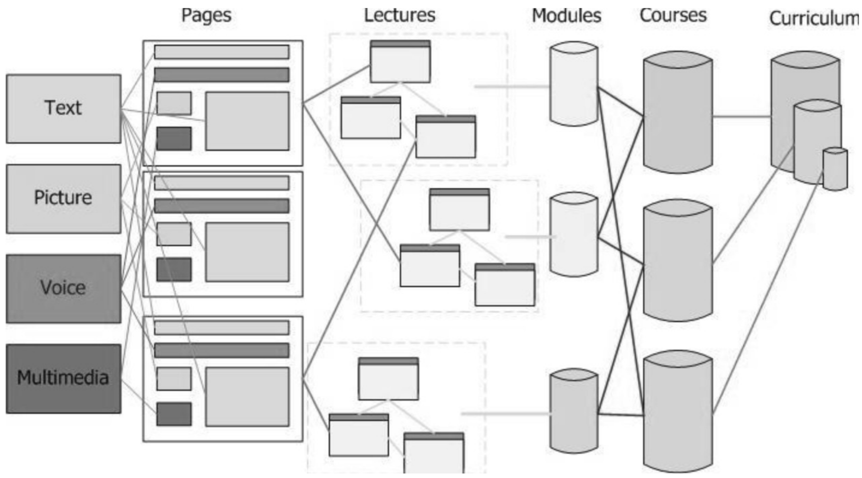

Fig. 2. Courses structure.

and information technology subjects and contains WnetSim and SIMAS simulators. WnetSim [22] presents an environment which allows students to visualize and simulate a process in a computer network with any topology; web-based educational computer system simulator SIMAS [23] provides for entering and compiling an assembly language program, as well as for loading and executing the resulting machine code.

Besides offering support to students during learning and understanding different information technology terms, Web laboratory enables a practical student knowledge evaluation through its simulators.

Moreover, teaching according to the student's level of knowledge is an important aspect in adaptive learning. It can be basic, intermediate, or advanced. The adaptation of teaching materials, that will fulfill those criteria, is a task for the teacher. This process is in its early stage.

Within this model, apart from lectures, the teachers are also able to place tests within the application.

It should be noted here that the teacher can manage only courses that s/he is responsible for in this system and therefore, teaching methods and media available will enable him/her to create teaching materials for subjects he is responsible for exclusively.

3.2 Student module

This is the key component in adaptive and intelligent learning systems. Student Profile is an abstract representation of learners in the adaptive learning system, which is the system's belief about learners [24].

First of all, the system must collect the data about students, and then process these data in order to set up the student profile. Next, the system must act according to the Student Profile, and adapt the system.

Information about the student is obtained in many ways, using different technique. Our system does not support constructing the student model from the student's reading and navigation, but from external sources, various kinds of tests (psychological and knowledge assessment).

Generating the student profile begins with students filling out their basic data and tests such as:

- Filling out their personal data, data about the school and the major they are attending (registration);
- Filling out the VARK questionnaire (available on address www.vark-learn.com). It offers sixteen statements in order to determine their learning style.

On the basis of these data the system recommends the student teaching materials which would suit best his learning style.

The student profile is based on gathered data and student's psychological characteristics formulated by predetermined rules or teacher's preferences.

According to undertaken surveys and by monitoring student's activities (during classes in the traditional way), conclusions can be drawn about an individual, for example, the learning/cognitive style and knowledge level which describes each student the best.

The Student Module is viewed as a set of the following data:

- Information data—general characteristics of the student;
- Profile data—data about the learning and cognitive style;
- Data history—learning process data (the system analyzes the results of the test, determines the

knowledge level of the student as well as making a suggestion for learning those modules for which the answers were wrong for each module of a course).

The student module generates and modifies the student profile in several steps: it gathers data about the student and forms a database of the student information profile, processes the gathered data, determines students psychological characteristics according to the defined rules and generates the database of the student's psychological profile, monitors the student's learning process and achieved results and forms a database of student's previous activities, modifies the profile of the student based on the data from the database of the student's previous activities.

In this manner every student is assigned a personal profile which is dynamically developed while students' personal information is constantly updated in the course of students' education. Furthermore, students have access only to the subjects and corresponding teaching materials from the course and the year they are enrolled. The same applies for viewing enrollment details, exams, corresponding test results and final marks.

3.3 The testing module

This is a third part of the learning management system. Courseware is structured in lessons (concepts) grouped in modules. Modules can be grouped in courses (Fig.2). Knowledge assessment are made from answers to various types of questions, and from students answers to these questions it is determined to what extent they understood the concepts.

Tests, as a student knowledge-evaluating activity, are created by teachers and allocated to students. To create an assessment, the following parameters have to be determined:

- accessibility—students use the test to help them study (online test), or for grading purposes (knowledge assessment);
- timing (limit for answering);
- assessment scale, question-selection criterion—for dynamically select questions from the database (fixed, random, or adaptive);
- test-finalization criterion.

This module will be presented in more detail below.

4. Knowledge assessment

According to Brusilovsky [25], the "life cycle" of a question in online assessments has been divided into three stages: preparation (before active life), delivery (active life), and assessment (after active life).

The knowledge assessment system enables the creation of questions through the module for question authorization (Fig. 3). Using an appropriate interface, it is possible to create different types of questions. Already stored questions can be altered—question text, answer text and other question parameters. In the process of question authoring, the ability to create complex question texts is very important. The text editor supports authoring of questions that consist of pictures, tables, animations etc. Apart from the above mentioned, when creating questions, the teacher must mark the following parameters (Fig. 3): the complexity of the question (hard—H, easy—E), the number of points the question is worth depending on the complexity and the module it belongs to. Marking modules enables the system, when generating the report at the end of testing, to give the recommendation for further learning of those areas (modules) where the questions were answered incorrectly. Parameter Answer Type refers to the following possible options: multiple choices, false/true, fill in the blank and drag and drop. Each of the options dynamically generates the form for filling in the answer. Figure 3 illustrates the use of multiple choices.

As soon as questions and correct/incorrect answers are defined and test cases supplied, it is possible to perform an assessment in the delivery stage.

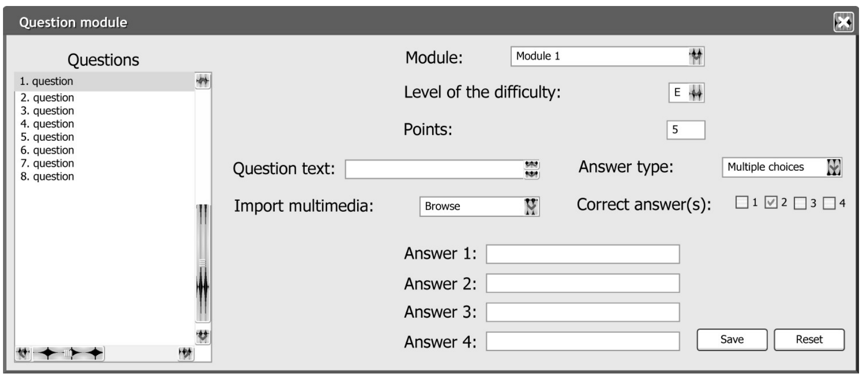

Fig. 3. Interface for question administration.

The delivery stage includes a question presentation, an interface for the student to answer the question and the retrieval of the answer for evaluation. This stage depends on the technology used for the learning system. For the delivery stage of an assessment in the ADES-TS system, there are windows and web-based learning environment. An assessment starts as soon as a student has logged on to the system and has entered a user name and password. The module for the presentation of an assessment question displays different question types differently but preserves the unique assessment page presentational characteristics. An assessment can be automatically evaluated at any moment. Students can check their answers at any time before submission. After this, the student can't change the answer.

At the assessment stage, the system evaluates answers as correct/incorrect, delivers feedback to the student, and records the student's performance. Once an assessment has been submitted, students cannot access it anymore. When a student submits the test, the system generates the final result accompanied with the full statistics of the test:

- total number of questions;
- number of correct, partially correct, and wrong answers, number of points scored (or percentage) by student;
- pass or fail message;
- recommendation for further study where answers were not satisfactory.

ADES-TS system allows for the following types of testing:

- preliminary (assessing the student's general level of knowledge);
- self-testing (self-assessment of knowledge conducted online, important interactive element for students);
- *progressive* (assessment of knowledge in different phases of the learning process) and final assessment (the final exam).

Each knowledge assessment contains various parameters defining the assessment termination (completion) criterion, number of questions to be offered to the student, etc.

Preliminary assessment is conducted within the subject that requires the student to possess a certain knowledge acquired in previous courses. Apart from that, according to preliminary assessment, the teacher determines the level at which lectures will begin. The level can be beginners, elementary, and advanced. If a given subject does not require previous knowledge, students will not have to pass a preliminary assessment.

The questions given to students in progressive and final tests are made up by the teacher, then stored in the same database.

Teaching courses are divided into teaching modules. Progressive assessment is accomplished when all required instructional sections—modules are completed (Fig. 4). At the end of the test the system will provide a summary score as well as a suggestion for re-learning those modules for which the answers were wrong. Final (integrated) assessment of students is carried out at the end of course. The system generates random questions from the same database as questions for progressive assessment.

Figure 4 shows the assessment process.

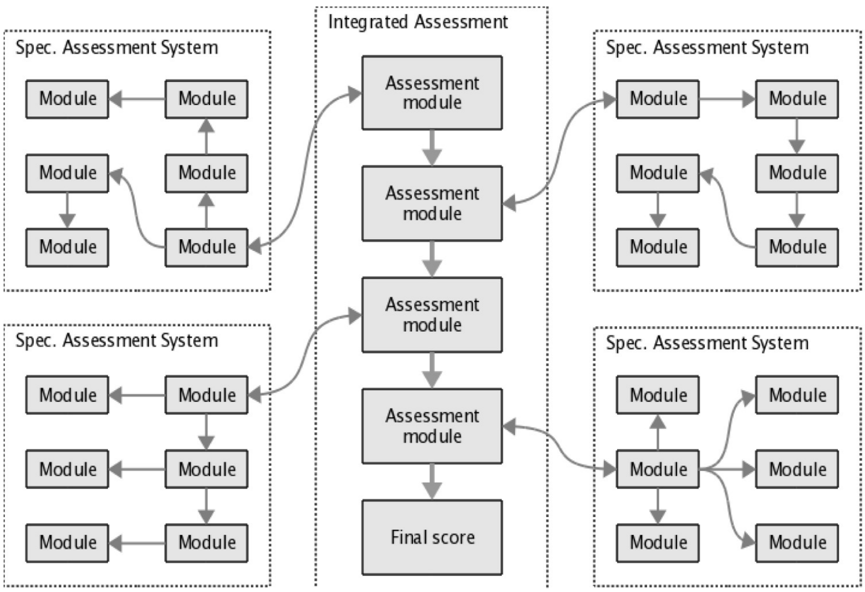

Fig. 4. Integrated assessment process.

Each of the mentioned types of testing is conducted in school using a Windows application except when the testing is done online. Short quizzes in the form of multiple choice questions are made available online for students who want to self-test or to improve their knowledge. Students, therefore, receive immediate feedback on whether their answers are correct, and what the correct response should be for each question.

Each knowledge test is defined by different parameters such as allowed time for submission of the test and the number of questions which will be offered to the students.

The above presents static testing performed within the system. The questions and possible answers and their sequence offered to the student for selection are randomly generated, which should ensure that each student is offered a different test.

5. Adaptive testing and rasch's single-parameter model

Unlike static knowledge assessment, which usually has a fixed number of questions presented to all students, the adaptive model uses dynamic knowledge assessment. Adaptive testing is based on Item Response Theory (IRT) [26]. This is a statistical model connecting the features of items and characteristics of an individual on the one hand, and the possibility of giving the correct answer on the other. IRT is based on the success of students in answering the given questions and the relation between that success and a group of independent factors (characteristics, latent characteristics, abilities). There are several types of models within IRT. The Rasch model is a simple IRT model. It is based on objective measurement [27]. Rasch's single-parameter model starts from the fact that the probability of giving the correct answer in relation to the observed ability (knowledge), depends only on one factor—the difficulty of the question.

The mathematical formula of the Rasch model is :

$$\mathrm{P}(\theta) = \frac{1}{1+e^{-(\theta-b)}}) \qquad (1)$$

Where: P is probability for an examiner responding correctly, θ is ability parameter of an examiner, b is difficulty parameter of an item.

Adaptive testing is applied only during the final test and is performed according to the algorithm given in Fig. 5. The questions presented are selected taking into account the student's individual performance during the test, or in other words, how each student answered previous questions. If the student correctly answers the presented question, then a more difficult one is presented next. But if the student's answer is incorrect, an easier question is presented next. This way, low-ability students will be presented with relatively easy questions, while high-ability ones will be presented with more difficult questions. The score will be determined from the level of the difficulty, and as a result, while all students may answer the same percentage of questions correctly, the high-ability ones will get a better score as they answer more difficult items correctly.

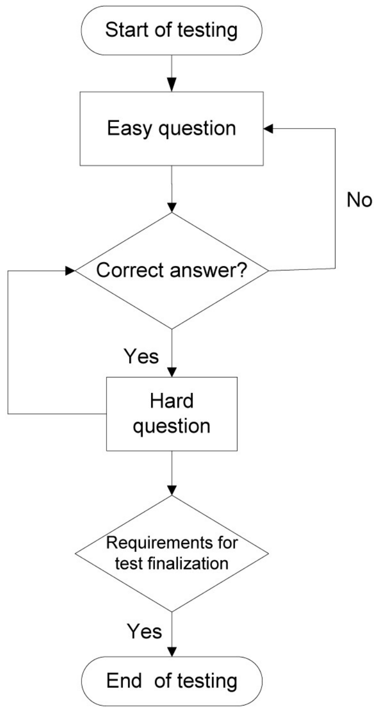

Fig. 5. Adaptive assessment.

The function is identified with this formula in Equation 2:

$$f(x, y) = \sum_{i=n}^{m} ax_i + by_i \qquad (2)$$

Where x represents the number of harder questions (which can be variable and depends on the students' level of knowledge), y represents the number of easier questions; a, b are quotients of difficulty. Index „i" refers to the number of modules of the course which is being tested.

The characteristics of adaptive testing in regard with static testing are that the teacher defines timing of the test, but there is no limitation imposed on the number of questions, which means that during the final test the number of easy and more difficult questions is varied, depending on answers previously given by students.

During the assessment, students can't check their answers, nor can they get back to previously answered questions.

Adaptive testing was applied in the school from this year, and although still in the experimental phase, has shown very interesting results.

6. Practical application and results

Uses of computers for testing students have introduced many advantages in the overall process of student examination and marking. Although, as highlighted previously, this is not the only method for examination, it surely represents an integral component.

All courses involving the use of a web laboratory demand, on top of theoretical tests, are a practical examination of students. In the last couple of years WNetSim and SimAs simulators were successfully utilized in the process of learning and examination of students.

Starting assumptions and objectives are based on pedagogical principles, experience, and analysis of some parameters such as educational level, learning style, systematic work, and expectations of students.

We have conducted a qualitative and quantitative evaluation of the system in the classroom. This analysis was focused on the evaluation of the instruction design for the system and has been conducted with the students of the Department of Computing and Informatics.

The data for this qualitative analysis were gathered by means of a paper-and-pencil survey. The questionnaire was distributed randomly to 263 students. Missing responses were found on questionnaires from 56 students. After using the ADES-TS for a few months, the 207 participants were asked to complete the questionnaire that included demographic information (gender and age) and two different components (e-learning experience, and attitudes toward e-learning). The questionnaires were distributed to participants during class. All subjects were asked to respond to the questionnaire and their responses were guaranteed confidentiality.

The surveys are aimed at learning what students perceived as a good educational tool and how they assessed the overall effectiveness of this approach. The initial student responses towards the system were encouraging and some of the received feedback inspired several improvements of the system's interface. Most students praised the system's graphical features and found it user friendly.

For example, the analysis confirmed that students using simulators were better prepared and had deeper understanding of basic concepts. The quantitative evaluation substantiated this subjective perception as the percentage of students passing the exam increased steadily since we started using SIMAS.

Table 1. Characteristics of students

Characteristics of students		Number	Percentage
Gender	Female	11	22%
	Male	39	78%
Age	19–24	29	58%
	25–30	17	34%
	31 and above	4	8%
Education levels	Basic	19	38%
	Intermediate	23	46%
	Advanced	8	16%
Learning style	Visual	18	36%
	Aural	4	8%
	Read/write	1	2%
	Kinesthetic	27	54%

The newest research in the field of adaptive testing which was conducted in the school is based on learning styles, which represent different approaches or ways of learning. While learning, every student gives priority to the information obtained through a certain sensory modality, and using that information learns in the most efficient manner.

The influence of learning style on the learning and examination process was demonstrated in a experimental group of students [21]. The course resulted in a significant increase in high marks and the learning experience feedback sheets showed that students were much happier about the course than in previous years.

Application of adaptive testing was introduced in our School from this year. Its influence on students, which is featured through increased students' motivation for the learning process and higher probability of passing exams, is given in Figure 6.

The experiment was conducted on a group of 50 students attending the course on Information System Design. Table 1 shows characteristics of student who were involved in the testing.

The students were divided into two equal groups. All of them attempted static progressive tests, but their final tests were different (Fig. 6).

Although statistical data were obtained during only four exam terms, it can be noted that students

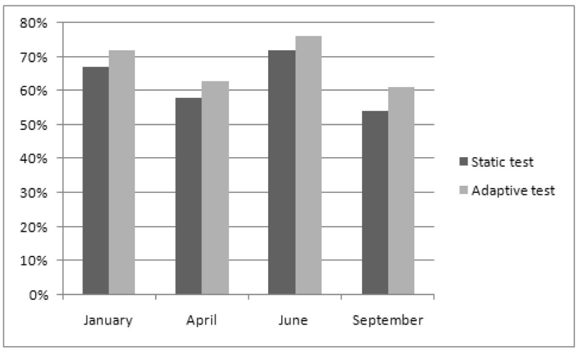

Fig. 6. Comparative analysis of static and adaptive testing.

who attempted adaptive testing were slightly more successful. This graph does not take into account the students' final mark, only the success rate of the final test. Figure 6 presents percentage success rate of both group of students versus exam terms. The introduction of adaptive testing certainly contributed to the improvement in the quality of not only the teaching, but examination as well. The effect of improvement, although negligible was certainly evident.

7. Conclusions

Development in information technologies resulted in improvement of the education process, especially its application in knowledge evaluation, grading, and ability for learning through computer supported tests and computer adaptive tests. These tests represent a more effective way to assess knowledge with the maximum usage of computers. Adaptability is noted in the ability to adjust to the knowledge of the student. Primary advantages in the presented method of examination are:

- creating individual and unique tests for every candidate;
- the smaller number of mistakes in case of different examiners;
- grading consistency; a higher level of test security (since it is not known which questions the individual student will get);
- a wide range of different question types;
- faster testing with the same level of security;
- instant feedback to students, giving precise results for the examined students with a wide range of knowledge.

Computer assessment of student knowledge has been conducted in the school for the last few years and proved to be very successful. Above all, most weaknesses of the teacher as the grader (the same criteria of assessment for all students) were removed. Statistics have shown that the success of students, from year to year, has a tendency to grow. There is a quantitative and qualitative progress in the sense of increasing the number of students who pass the exam and also with very good grades.

In addition to offering support to students during learning and understanding different information technology terms, a web laboratory enables a practical student to evaluate knowledge through its simulators. The analysis confirmed that students using simulators were better prepared and had deeper understanding of basic concepts.

Developing e-learning systems that adapt to student learning style is not a trivial task. Design and development include selecting the appropriate learning style model, creating course content consistent with the various learning styles, determining the level and degree of adaptation of domain content, and creating appropriate tests for each student according to knowledge level and learning style.

In order to offer the possibilities of contemporary testing to our students, the created system has been experimentally used at the school. The experiment has shown that in our circumstances it is also possible to implement testing by applying IT and logic of computerized adaptive testing, and to open the doors for further research and improvement. The introduction of adaptive testing certainly contributed to the improvement of the quality of not only teaching, but examination as well. The effect of improvement, although negligible was certainly evident.

The next stage of our project will be the composition of the curriculum, with module-connected courses as a specific basis of knowledge in teaching lessons and answering questions. In order to realize them we will use different multimedia elements which would suit different learning styles of students.

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