ADAPTIVITY OF TESTING IN EDUCATION PROCESS

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Abstract: *Testing has always been and will be ~~a~~ part of the educational system. Pupils are tested when they start attending a new school, when they graduate and during the course of their studies. The testing results have an impact not only on the pupils, but also on the institution – school: How successful was the school's result compared to other schools? What was the school's position in the evaluation chart? Can the school defend the results when facing the competition of other schools? The paper is aimed at introducing the possibilities of alternative testing – adaptive electronic testing.*

Keywords: testing, adaptive electronic testing, repetition with consultation mode, test questions and tasks.

INTRODUCTION

As far as the Czech pupils are concerned, there are still differences between their knowledge and skills. The pupils, who tend to achieve good results, have a similar level of knowledge and skills. The problematic students, the ones slower in understanding the curriculum, often require a more personal approach, additional materials, demonstrations or a step-by-step explanation of the solving process. Is it in the teacher's powers to do it? In the present state, when it is not unusual that there are as many as thirty pupils in the classroom, it is impossible for the teacher to treat each pupil individually and take their individual needs into account.

The use of an adaptive system (a suitable LMS) containing study materials and a large number of test tasks and questions referring to the current curriculum seems to be an appropriate choice. The test tasks and questions are divided into individual categories according to the level of difficulty. Each task contains the so-called Link (I am not sure about the answer and want to look at the Link which refers to the curriculum related to the test task). Moreover, each task also contains the so-called

Help (I do not know the answer and want to look at the Help, which offers the entire solving process and the correct answer).

What is the principle of adaptive testing? It is a selection of test questions and tasks adapted to the tested pupil's current level of knowledge. While the typical test cannot be adapted to the pupil's individual needs, the adaptive LMS can. Each pupil who participates in adaptive testing begins with a task from the intermediate level of difficulty. If the pupil answers correctly, the following task is from the more difficult category. If the pupil answers incorrectly, the following task is from the less difficult category (in this case the pupil can use the Link and Help).

1. BARBORKA LMS AND ITS CONTENT

Which system was used for storing test questions and tasks? The adaptive LMS Barborka 4, which was developed by a group of informatics within the scope of the cooperation of the Faculty of Electrical Engineering and Computer Science of the VŠB-TU and the Department of Information and Communication Technologies at the Pedagogical Faculty of the University of Ostrava (for more detailed information see Takács, 2014).

In order for the LMS to work properly in adaptive testing, it has to contain test questions and tasks that fulfill particular criteria:

1) The created tasks should be in accordance with the current Framework Educational Program (FEP) and should be aimed at the development of key competencies,
2) As far as the educational content is concerned, the created tasks should fall within thematic areas of Mathematics and its application;
3) The created tasks should be automatically evaluable (for the purpose of electronic testing) and divided into groups according to the level of difficulty.

1.1 FEP and key competencies

As far as the Czech Republic is concerned, a new system of curricular documents is used for the education of pupils between 3-19 years of age. The system has two levels – state and school. The state level includes **framework educational programs (FEP)** which determine the individual stages of education: preschool, primary and secondary education. The school level includes **school educational programs (SEP)**, which are created by each school individually according to the rules and principles stated in the particular FEP.

Framework educational programs formulate the expected level of education which is determined for the pupils of individual stages of education. Moreover, they specify the level of key competencies, which the pupils should acquire by the end of primary education, and define the educational content.

The main goal of primary education is the formation and continuous development of **key competencies**.

The term key competencies includes knowledge, skills, abilities, approaches and values which are essential for the personal development of an individual and their role in society.

According to the latest FEP (2013), the key competencies of primary education are the following (italicized are the competencies which were emphasized during the creation of test tasks and questions):

- Learning competencies

  The pupil can *collect, sort and connect information* in a relevant manner; work with various learning strategies and methods; experiment and observe; uses commonly known terms and symbols.

- Problem solving competencies

  The pupil encounters various problems; *can think critically and find constructive solutions*; uses various points of view to deal with problems; tries to verify the results in practice and use them when solving similar problems.

- Communication competencies

  The pupil can formulate their ideas and opinions in a logical order; uses information and communication technologies to communicate with the world; *understands image material, various types of texts and records*.

- Social and personal competencies

  The pupil can work in a group, becomes a team member; cooperates with their fellow pupils; is able to discuss both in a small group and in the classroom.

- Civic competencies

  The pupil respects other people's opinions; understands basic social norms; can empathize with other people's feelings; understands basic environmental and ecological problems.

- Work competencies

  The pupils can use the *knowledge and experience acquired in individual courses* in their further development; makes a decision concerning their further professional growth.

1.2 Educational area Mathematics and its application

As far as FEP is concerned, the educational content of primary education is divided into nine educational areas. One of the areas is **Mathematics and its application**. In this course the educational content is divided into four thematic areas: *Number and variable; Dependency, relations and working with data; Geometry in plain and space; Non-standard application tasks and problems*.

Primarily, the Barborka LMS contained tasks which should test the knowledge and skills of the 9th grade elementary school pupils. Therefore, the abovementioned thematic areas were further divided into six categories: *Number and variable; Terms and equations; Data, graphs and charts; Functions, Geometry in plain, Geometry in space*. 25 theoretical questions and tasks were created for each area. Theoretical questions test definitions while practical tasks require solving. Moreover, for each task two other equivalent tasks were created – different in formulation, numerical values or the provided versions of answers (450 test tasks altogether). The following are assigned to each task: the already mentioned Link – which refers to the curriculum related to the test task and Help – which offers the entire solving process and the correct answer.

1.3 Formal and content classification

On the basis of formal classification the tasks were divided into automatically evaluable and automatically non-evaluable (the automatically evaluable tasks are suitable for the purposes of electronic testing). On the basis of Dana Tollingerová's taxonomy of educational tasks (1970) and a detailed analysis the content classification with five categories was created, which represent the five levels of difficulty (in order to achieve adaptivity – adaptation to the tested pupil's individual needs).

2. TESTING TASKS

After accepting all the criteria the testing tasks were created. Here are examples of tasks from each thematic area.

Number and variable

Decide if the following are true:		
$12 * (0{,}6 - 0{,}4) = 1{,}2 * (6 - 4)$	YES	NO
$244{,}2 : (-11) \neq 2{,}22 * (-100)$	YES	NO
$0{,}53 * (-0{,}5) = 1{,}2 * 0{,}24$	YES	NO
$9 + 12 \neq 25 - 4$	YES	NO

Terms and equations

Write correct answer

If we increase three times the number x by one half, we get four times the number x minus 2. What is number x?

The solution is: _____

Data, graphs and charts

Decide if the following are true.

The teacher summarized test grades. The results are in the chart.

Grade	N. of students	Number
1	IIII	4
2	IIII I	5
3	IIII	4
4	III	3
5	II	2

a) There are 18 pupils in the classroom. YES NO

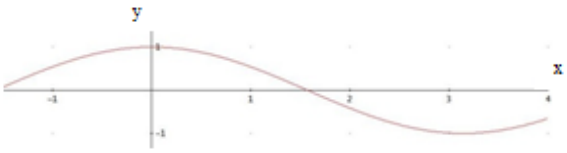
b) The average test grade is 2.4. YES NO

c) Half of students have an A or B. YES NO

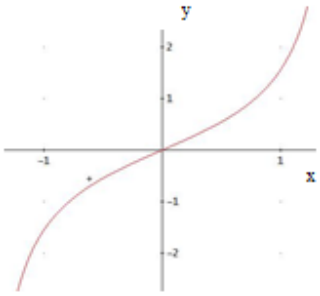
d) 1/9 of pupils have an F. YES NO

Functions

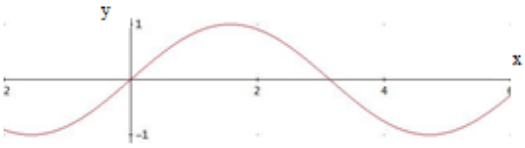
Assign correct functions to the graphs:



$\sin x$ / $\cos x$ / $\tan x$ / $\cot x$



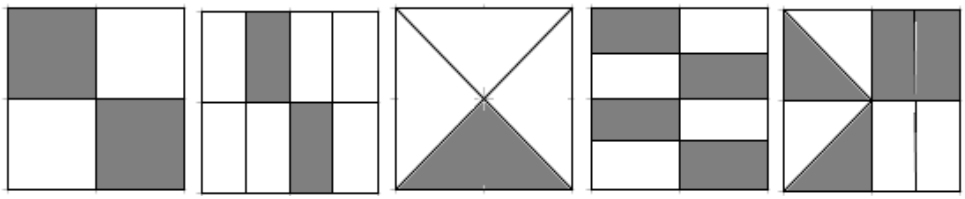
$\sin x$ / $\cos x$ / $\tan x$ / $\cot x$



$\sin x$/$\cos x$/ $\tan x$/ $\cot x$

Geometry in plane

Using a fraction in the basic form, write under each picture what portion of it is colored (example 1/5).



[ ] [ ] [ ] [ ] [ ]

Geometry in space

Make correct pairs (using arrow-heads):

a) Surface of a sphere with a radius 10 cm is	1. 1256 cm^2
b) Surface of a sphere with a radius 25 cm is	2. 2122,64 cm^2
c) Surface of a sphere with a radius 15 cm is	3. 2826 cm^2
d) Surface of a sphere with a radius 13 cm is	4. 7850 cm^2

3. ADAPTIVE ELECTRONIC TESTING

The theory of the adaptive testing method (TATM) is derived from the Theory of adaptive learning (TAL) (Kostolányová, 2013), which contains the proposed process of the Virtual Teacher. According to the TAL, the education process is realized by the already mentioned adaptive Barborka LMS.

Where can adaptive electronic testing be applied? Firstly, we can mention what phases the pupil learning a new curriculum is going through:

1) First reading, 2) Instruction, 3) Repetition with consultation concerning the problematic parts, 4) Self-testing

The TAL deals with the first two phases while the TATM deals with last two phases – the Repetition with consultation and Self-testing phases. It is based on the **testing of the level of knowledge** before the pupil takes the exam. It can be expected that in this learning phase the pupil does not yet have the required knowledge. Adaptive electronic testing is based on the division of tasks into **a number of difficulty levels** from the less demanding to the most demanding (as was already suggested by Komenský). By the continuous solving the pupil verifies their knowledge and skills, tests the current knowledge and learns about their gaps, in the context of the failed task the pupil can learn from their mistakes or be re-taught the particular part of the curriculum (they are provided with the Link – which refers to the study material).

What does the way through the adaptive test look like? The following flowchart of the Repetition with consultation mode provides a simplified picture of the way through the adaptive test:

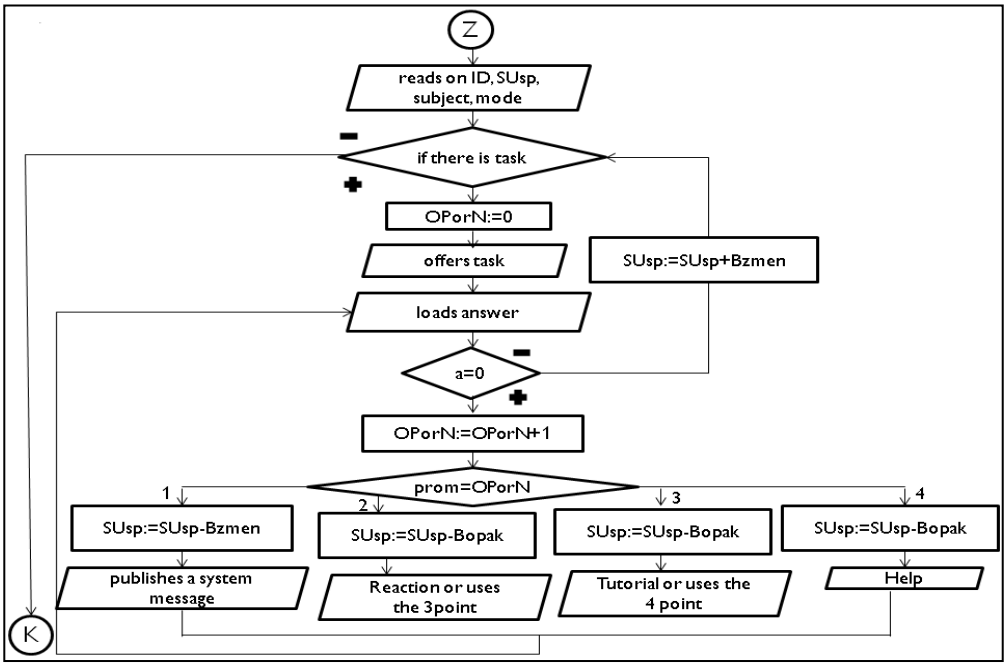


Figure 1. Repetition with consultation mode flowchart

Source: My own paper (Prextová, 2014)

For clarification, the following is the verbal description of the algorithm (Prextová, 2014):

1. Loads the current pupil's id.
2. Loads the current Susp value (for a new pupil the Susp value is set to the mean value Susp = 50, for a known pupil the Susp value is set according to the success rate of their previous sessions).
3. On the basis of the pupil's choice of subject, unit or the repetition mode, the algorithm manages the education according to the following procedure of the repetition with consultation:

   If there are tasks in the sequence of tasks of the chosen subject (unit), then:

   - From the current Susp value the algorithm calculates the pupil's current Obod value,
   - CT uses the Choose the Task procedure and offers the pupil one task of an Obod difficulty corresponding to their current Susp,

- Loads the pupil's answer and evaluates it,
- If the answer is correct, it increases the Susp value by the Bzmen value, otherwise
    i. If the answer is not correct the first time, it publishes a system report about the incorrectness of the answer and offers the pupil a second attempt; it lowers the Susp value by Bzmen;
    ii. If the answer is not correct the second time,
        - Lowers sUsp by Bopak,
        - If there is a Reaction (the expected or general incorrect answers) to the answer, it offers the pupil the Reaction, or uses iii,
    iii. If the answer is incorrect the third time,
        - Lowers sUsp by Bopak,
        - If there is a reference to the particular link to consultation as a context instruction in one of the previous layers, it offers the pupil the layer, or uses iv,
    iv. If the answer is incorrect the fourth time,
        - Lowers sUsp by Bopak
        - If there is Help, it offers the pupil a similar solving process with a correct result and invites them to copy the result; or simply offers the correct result.
- Records the pupil's result to the education protocol and to the pupil's task matrix.
- The end of the cycle for the series of subject (unit) tasks.

4. Notifies the pupil about the overall Susp result (transformed to a grade, if need be).

4. VERIFICATION IN PRACTICE

The algorithm for the Repetition with consultation mode was put into practice and tested on the sample of 53 pupils. At the beginning of the experiment, each pupil was assigned a unique identification code, which they had for the entire time of the experiment (all of its phases). In the first phase the pre-test was realized. In order to verify the efficiency of the six thematic areas, six versions of pre-test were created, each of which consisted of nine tasks. The first five tasks were of intermediate difficulty while the remaining four tasks were of gradually increasing difficulty.

In the second phase the Barborka 4 LMS was put into service. The subject Mathematics – which consists of six thematic areas (units) – was inserted into the system. Each unit has five frames (see Šarmanová, 2011) and each frame has five test tasks of different difficulties. The Link (through which the pupil gains access to the current study material) and Help (which offers the entire solving process and the correct answer) are assigned to each task. All pupils who took the pre-test were logged into the system. Moreover, the pupils were instructed in detail about how to work with the system. The thematic area (unit) on which the pupil focuses in the system is based on which of the six samples of the test they take. During the course of one week the pupils had the opportunity to work with the system, test themselves and improve in the solving of the task which they found to be the most problematic.

In the third phase the post-test was realized. Again, six versions of post-test were created, each of which consisted of nine tasks equivalent to those of the pre-test.

What were the results? The processing of the results into a chart and a graph showed that each of the tested pupils displayed a statistically significant improvement of their level of knowledge in each of the six thematic areas. Moreover, as far as the entire Mathematics course is concerned, the results proved that the pupils improved their knowledge.

CONCLUSION

It can be stated that the proposed algorithm for adaptive testing (particularly for the Repetition with consultation mode) is a valuable contribution to the field of education. Each pupil is assigned a task the difficulty of which is based on the pupil's answer to the previous task. It maintains individuality by respecting each pupil's level of knowledge. As a result, by providing the pupil with immediate feedback in the form of study material or Help, it eliminates the stress of not being able to answer a question correctly. With every successive repetition the pupil's knowledge is improving, which leads to the improvement of the overall level of knowledge.

As far as the teacher is concerned, it is important to distinguish which thematic area the pupils find the most problematic, which types of tasks they find to be the most problematic, in which manner the tasks and possible answers should be formulated, whether or not the presented solving process is sufficient or if the task needs to be explained differently, etc.

ACKNOWLEDGEMENT

The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement No: PIRSES-GA-2013-612536 and statutory research.

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